POWER PLANT ENGINEERING

Established Over 32 Years

VOL. XXXII CHICAGO, AUGUST 1, 1928 No. 15

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Published on the 1st and 15th of each Month by the

Technical Publishing Co., 53 West Jackson Blvd., Chicago

New York Office, 171 Madison Avenue

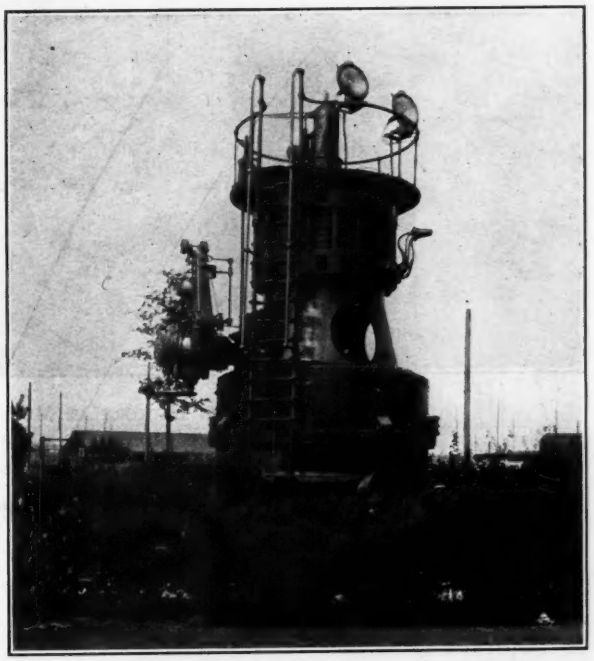
Subscription price $2.00 a year in the United States and possessions. Canada $2.75 a year. Other countries $3.50 a year. Single copies 15 cents.

Copyright 1928, by Technical Publishing Co.

Entered as second class matter May 1, 1908, at the Post Office at Chicago, Illinois, under the act of March 3, 1879.

Member, Associated Business Papers, Audit Bureau of Circulations.

Circulation of this Issue 23,900



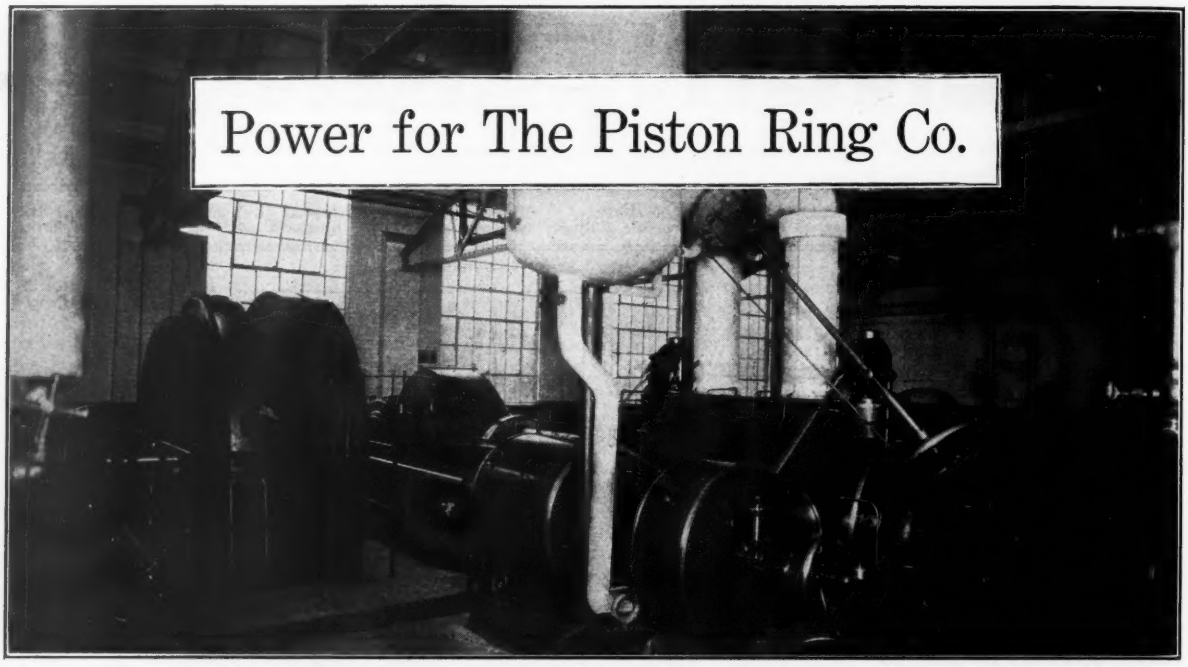
World's Largest Yard Unit

ALWAYS THE FIRST with the latest is the watchword of The Milwaukee Electric Railway and Light Company. Having pioneered pulverized coal and high pressures, it is now actively pushing the yard unit shown above as the latest central station development. In fact, it claims to have the world's largest unit for this service.

In rainy weather, the water rate is high but as the unit was pensioned off years ago nobody seems to worry greatly about its performance. The machine is one of the pioneers not only of this company but of the electrical industry and justly deserves the place of honor it occupies in front of Lakeside Station.

At night, it is floodlighted and, set in the midst of shrubs and flowers, adds materially to the appearance of the station. Improving the appearance of power plants is a live issue with all central station and industrial companies at the present time and some of them have gone as far as introducing award systems for good housekeeping.

Details of such an award system, as worked out by Pacific Gas & Electric Co. for its various properties, are given on page 819 of this issue. Although none of these P. G. & E. plants can boast a yard unit, at the same time a most creditable showing is made in the maintenance of attractive plants and surroundings by the operating force.



Power for The Piston Ring Co.

To Serve Growing Factory at Muskegon, Mich., Company Installs Up-to-Date Plant, Containing Uniflow Engine, Stoker-Fired Boilers, Combustion Control and Incorporating Interesting Features of Design

PREVIOUS TO THE ERECTION in 1927 of the new power plant of The Piston Ring Co., Muskegon, Mich., it had been evident to the company for a considerable time that such a plant would eventually be needed to serve its constantly growing factory buildings. The only available space for a new power plant was that occupied by an old foundry building, therefore plans were made to use this and, in all the necessary wiring and piping that had to be done, precautions were taken to extend electrical leads and piping connections in that direction. When it was definitely decided to build the new power plant, F. W. Dyer, plant engineer for the company, was given entire charge of design and construction and he had his general course of procedure well in mind, with a good start already made. Thus, in 1927, on the site of the old foundry, the plant described here was erected.

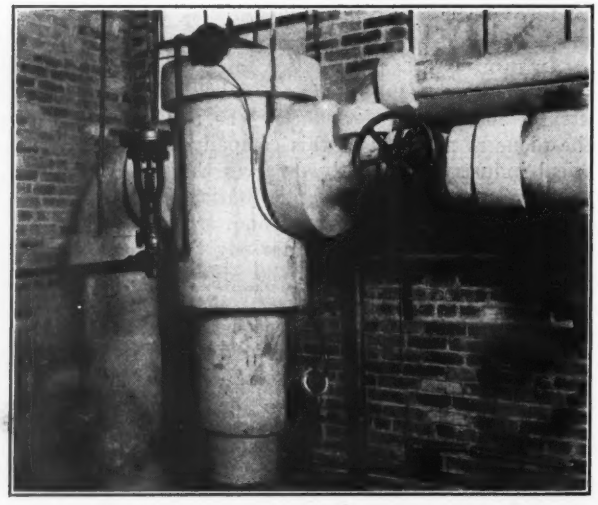


FIG. 1. THIS EQUIPMENT DESUPERHEATS LIVE MAKEUP STEAM FROM BOILERS FOR HEATING SYSTEM WHEN THERE IS INSUFFICIENT EXHAUST

Plant Designed to Fit Industrial Conditions

Two stoker-fired boilers were installed, with space left for a third and a coal handling system was put in that has several interesting features. Electric power is generated by a uniflow engine driving an alternator that makes 30-cycle power; this frequency was used because all the mill equipment was designed for it, much of the equipment having been previously served by the 30-cycle transmission lines of the public utility company in that region. Steam is desuperheated for the heating system, boilers are governed by complete automatic control and full complement of instruments is provided. The entire plant is representative of many of the latest developments in small plant design, neither too conservative nor too radical but worked out to fit the particular operating conditions by a man thoroughly familiar with the power requirements of the industrial processes.

Boilers Generate Superheated Steam

Two water-tube boilers of the ring-circuit type, each with 2550 sq. ft. of heating surface, make steam for the plant, Figs. 3 and 4E. These are set with standard refractory settings, as shown, and with superheaters set vertically, a rather uncommon arrangement. No economizers or air preheaters are used. Steam is generated at 150 to 175 lb. pressure, with 150 deg. of superheat,

or a total temperature of 530 deg., at 100 per cent of rating.

Each boiler is fired by a single retort underfeed stoker, Fig. 4E, designed with its setting to operate the boiler at a maximum of 300 per cent of rating. A steam cylinder with its valve mechanism, incorporated in each stoker, forms the driving mechanism. Kentucky nut, pea and slack coal is the usual fuel, containing 13,000—13,500 B.t.u. per lb.

Grates of the stokers are designed so that with each stroke of the coal ram, a rocking motion is given to the grate section resting on the central support known as the rocker sector. The rocking of this grate section imparts an undulating motion to the entire grate mechanism to keep the fuel bed broken up. Controls at the front of the stoker govern the grate mechanism, stoker speed and steam ash dump mechanism. The grates are designed to admit and distribute air in the proper proportions to the various parts of the fuel bed.

Combustion air for the stokers is supplied by a steam engine-driven fan located in the engine room which adjoins the boiler room. This fan is large enough to serve three boilers, the existing two and a third future unit for which space is provided. Air ducts are designed for such possible future expansion.

Coal and Ash Handling Equipment

Coal handling equipment embodies a unique feature suggested by Mr. Dyer: a scraper conveyor without a bottom running over the main storage bunker. This bunker is suspended above the firing aisle, Fig. 1, and holds about 150 t. of coal. A bucket elevator takes coal directly from the cars in which it is received, which dump to a track hopper just outside one corner of the plant, Fig. 2. The elevator carries the coal up to a hopper in a pent house, from which a spout takes it down at an angle to the scraper conveyor. As stated,

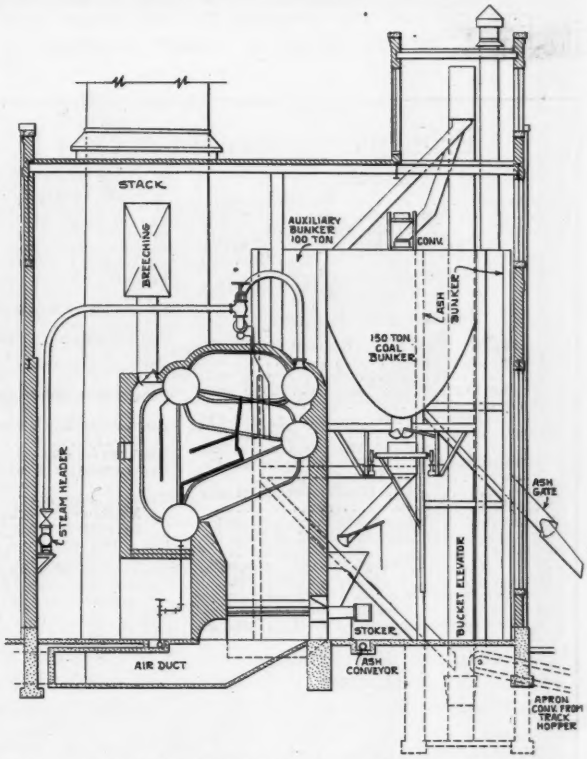


FIG. 3. BOILER ROOM LAYOUT IS SIMPLE, AS IT CONTAINS ONLY BOILERS AND COAL HANDLING EQUIPMENT

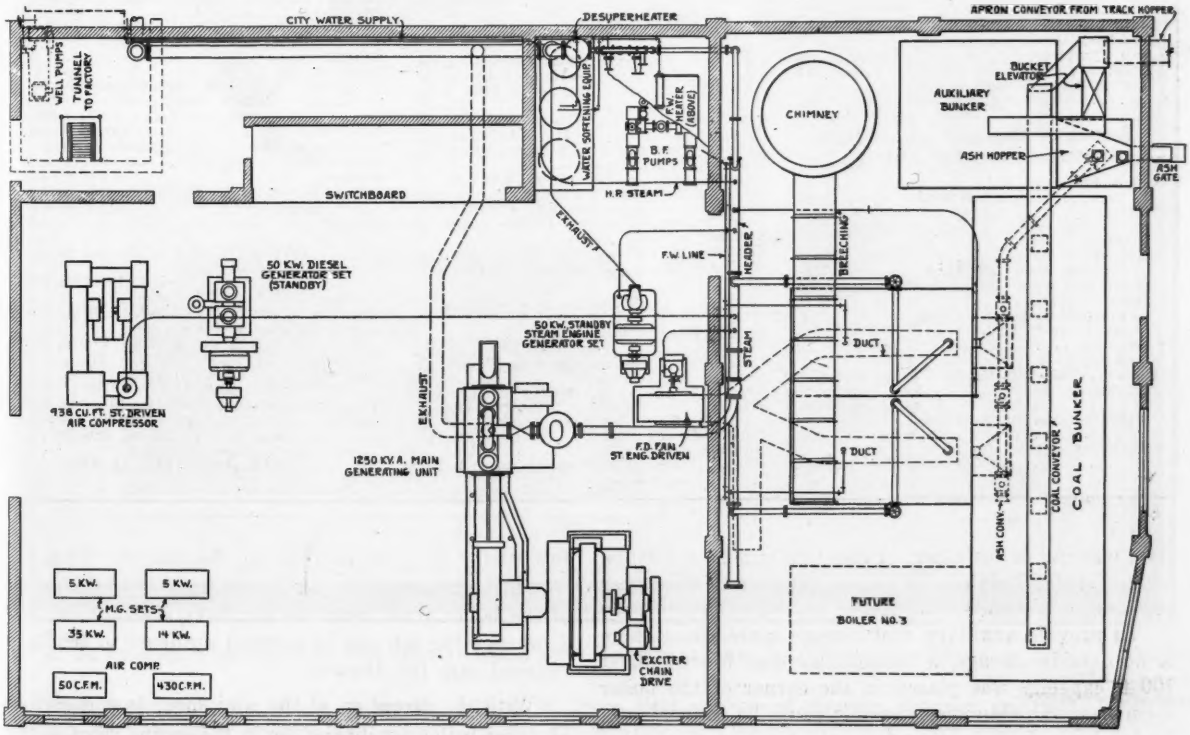


FIG. 2. GENERAL PLAN, SHOWING AUXILIARIES IN ENGINE ROOM, STEAM AND EXHAUST CONNECTIONS TO MAIN AND STANDBY UNITS

this scraper conveyor, where it runs over the bunkers, has no bottom and the flights of the conveyor merely scrape the coal into the bunker. It can be seen that when the end of the bunker is filled to the top, the conveyor will just keep scraping the coal along, over the top of the pile, filling the bunker progressively bucket elevator again, which will transfer its contents to the main bunker, either for emergency supply or to prevent storing the coal long enough to cause a fire.

Ash from the stokers drops into a rather shallow ash pit from which it is hoed out through a door directly into the loading ports of a steam jet ash conveyor, set

Principal Equipment in New Power Plant of The Piston Ring Co.

General

LOCATION ..... Muskegon, Mich.
SERVICE ..... Industrial steam and power
CAPACITY ..... 1100 kw., 30,000 lb. of steam per hr. at 200 per cent of rating
DESIGNED BY ... F. W. Dyer, Chief Engineer
CHIEF OPERATING ENGINEER .....
..... James T. Sullivan

Boilers and Stokers

BOILERS ..... Kidwell Boiler Co.
Number 2
Type ..... Tu-flo, ring circuit
Heating surface, sq. ft. ..... 2550 each
Steam pressure .....
.... Designed, 200; operating, 150-175
Steam temperature .....
..... 530 deg. at 100 per cent rating
SUPERHEATERS ..... The Superheater Co.
Number 2
Type ..... Elesco, set vertically
Superheat .....
..... 150 deg. at 100 per cent rating
STOKERS ... Westinghouse Elec. & Mfg. Co.
Number 2
Type ..... Single retort, underfeed
Drive ..... Steam cylinder incorporated in stoker mechanism
Coal burned .... Kentucky nut, pea and slack. Ave., 13,000-13,500 B.t.u. per lb.

Coal and Ash Handling Equipment

COAL HANDLING EQUIPMENT .....
..... The Jeffrey Mfg. Co.
Capacity ..... 45 t. an hour
Conveyors ..... Apron, bucket, scraper
Drive ..... 480-v.
G. E. ind. motors, one 5-hp., two 3-hp.
Weigh larry .....
..... Hand operated, 1000-lb. capacity
COAL BUNKERS .....
..... Rodgers Boiler & Burner Co.
Main bunker ..... Catenary, 150-t.
Auxiliary bunker ..... Rectangular, 100-t.
ASH CONVEYOR .... United Conveyor Corp.
Type ..... Steam jet
ASH STORAGE HOPPER .....
.... Rodgers Boiler & Burner Co., 15-t.

Boiler Accessories and Other Mechanical Equipment

SOOT BLOWERS .....
..... Diamond Power Spec. Corp.
PIPING ..... Geo. B. Limbert & Co.
PIPE INSULATION .... Johns-Manville, Inc.
VALVES:
Blowoff ..... Yarnall-Waring Co.; The Lunkenheimer Co.
Steam and water ... The Lunkenheimer Co.
Safety .....
Consolidated Ashcroft Hancock Co., Inc.
Atmospheric relief ..... Cochrane Corp.
Reducing ..... Mason Regulator Co.
Back pressure (on engine exhausts) ..
..... Cochrane Corp.; Illinois Eng. Co.
WATER COLUMNS .....
..... Reliance Gage Column Co.
Water column illuminators .....
..... National Co., Inc.
GRATINGS AND STAIRS .....
..... Kerlow Steel Flooring Co.
ELECTRIC CLOCKS ... Stromberg Electric Co.
WINDOW MONORAIL .....
..... Cleveland Crane & Eng. Co.
METERS AND INSTRUMENTS:
Orsat ..... Hays Corp.
Indicating pressure gages .....
American Schaeffer & Budenberg Corp.
Pressure and temperature recorders ..
..... Taylor Instrument Cos.
Steam flow meters and draft indicators
..... Bailey Meter Co.
Condensation meters .....
..... Central Station Steam Co.
COMBUSTION CONTROL SYSTEM .....
..... Hagan Corp.
FEEDWATER REGULATORS .....
..... (S-C) The Swartwout Co.
RECEIVING TANK CONTROL .....
..... Fisher Governor Co.
DESUPERHEATER ..... Elliott Co.
Desuperheater control .....
..... (S-C) The Swartwout Co.
STEAM TRAPS ..... Armstrong Machine Works, Sterling Engineering & Mfg. Co., Morehead Mfg. Co.
OIL SEPARATORS .....
... Elliott Co., Illinois Engineering Co.
STEAM SEPARATORS ..... Hoppes Mfg. Co.
LUBRICATING OIL FILTER and lubricators—main engine .....
..... S. F. Bowser & Co., Inc.

Pumps and Water Treatment Equipment

WATER SOFTENER .....
..... Paige & Jones Chemical Co., Inc.
Type ..... Zeolite
Number 1
Capacity ..... 4500 g.p.h.
FEEDWATER HEATER ..... Hoppes Mfg. Co.
Number 1
Type ..... Open, deaerating
Capacity ..... 1000 hp.
BOILER FEED PUMPS .....
..... American Steam Pump Co.
Number 2
Type ..... Simplex, steam driven
Size ..... 10 by 6 by 12 in.
Capacity ..... To serve 1000 b.hp.
Head ..... 200 lb.
Governors ..... Fisher Governor Co.
Lubricators ..... Hills-McCanna Co.
VACUUM PUMPS. American Steam Pump Co.
Number 1
Capacity ..... To serve 70,000 sq. ft. direct radiation at 8 in. vacuum
Type ..... Simplex, steam-driven
SUMP PUMPS .. American Steam Pump Co.
Number 2
Capacity ..... 35 g.p.m.
Well pumps ..... Goulds Pumps, Inc.

Fans and Draft Equipment

BOILER BREECHINGS .....
..... Muskegon Boiler Works
CHIMNEY .... General Concrete Const. Co.
Number 1
Type ..... Reënforced concrete
Size ..... Diameter, 6 ft. 6 in. at top; height, 195 ft.
FORCED DRAFT FAN ..... Clarage Fan Co.
Number 1
Size ..... No. 90, designed for 3 boilers
Drive ..... Clarage vertical, 5 by 5-in. steam engine

Prime Movers, Compressors and Auxiliaries

MAIN GENERATING UNIT:
Steam engine ..... Nordberg Mfg. Co.
Number 1
Type ..... Poppet valve, uniflow
Cylinder ..... 28-in. bore, 40-in. stroke
Speed ..... 150 r.p.m.
Steam pressure, throttle ... 150-175 lb. gage (des. for 170 lb.), 100 deg. sup.
Exhaust pressure ..... 1.5 lb. gage
Main generator ... Allis-Chalmers Mfg. Co.
Number 1
Capacity ..... 1250 kv.a., 0.8 p. f.
Voltage 480-v., 3-phase, 30-cycle
Exciter ..... Allis-Chalmers Mfg. Co.
Number 1
Capacity ..... 125 v. d.c.; 125-165 amp.
Drive ..... Mounted on bearing pedestal, driven by Link-Belt silent chain
STANDBY GENERATING UNIT:
Diesel engine .... Fairbanks, Morse & Co.
Number 1
Type .. 2-cyl., 2-cycle, Diesel, solid injection
Generator .. Westinghouse Elec. & Mfg. Co.
Capacity .. 50-kw., 480-v., 30-cycle, 3-phase
Speed ..... 300 r.p.m.
Exciter ..... 8¼ kw,.
125-v. Westinghouse, direct connected
STANDBY GENERATING UNIT:
Steam engine .....
..... Engberg's Elec. & Mech. Wks.
Number 1
Type ..... Vertical, single-cylinder, steam
Size ..... 9 in. by 10 in.
Throttle pressure ..... 150-175 lb. gage
Exhaust pressure ..... 1.5 lb. gage
Speed ..... 300 r.p.m.
Generator .. Westinghouse Elec. & Mfg.. Co.
Capacity .. 50-kw., 480-v., 30-cycle, 3-phase
Exciter 8¼-kw.,
125-v., Westinghouse, direct connected
AIR COMPRESSOR ..... Ingersoll-Rand Co.
Number 1
Type ..... Imperial, Type 10, cross-compound steam cylinders, duplex air cylinders
Capacity, free air ..... 938 c.f.m.
Lubricator ..... Manzel Bros.
AIR COMPRESSOR ..... Ingersoll-Rand Co.
Number 1
Capacity ..... 430 c.f.m.
Drive .. Belted to G. E. 75-hp. ind. motor
AIR COMPRESSOR ..... Curtis & Co.
Number 1
Capacity ..... 50 c.f.m.
Drive ..... Belted to Howell motor
MOTOR GENERATOR SETS .....
..... General Electric Co.
Number 2
Capacity, each ..... 5 kw., 110 v., d.c.
MOTOR GENERATOR SETS .....
..... Westinghouse Elec. & Mfg. Co.
Number 2
Capacity .....
One 14-kw.; one 35-kw., 220-v., d.c.
TRANSFORMERS ..... Packard Electric Co.
Number ..... 3 for lighting service
Capacity, each ..... 75 kv.a.; 480-120 v.
MAIN SWITCHBOARD, complete .....
..... Westinghouse Elec. & Mfg. Co.

from one end to the other. From this bunker a 1000-lb. hand-operated weigh larry carries the coal to the stoker hoppers.

To provide auxiliary coal storage space, since there is no outside storage, a rectangular coal bin of about 100 t. capacity was placed in the corner of the boiler room near the chimney, where it could be conveniently loaded by a chute leading from the head of the bucket elevator. This auxiliary bunker can be emptied into the just under the floor in front of the stokers. This conveyor discharges to an ash storage hopper in the corner of the boiler room near the auxiliary coal bunker, Fig. 2, whence the ash can be spouted outdoors to trucks or railroad cars for disposal.

With the exception of the equipment just described, all other boiler auxiliaries are in the engine room so that they will be under the observation of the chief engineer

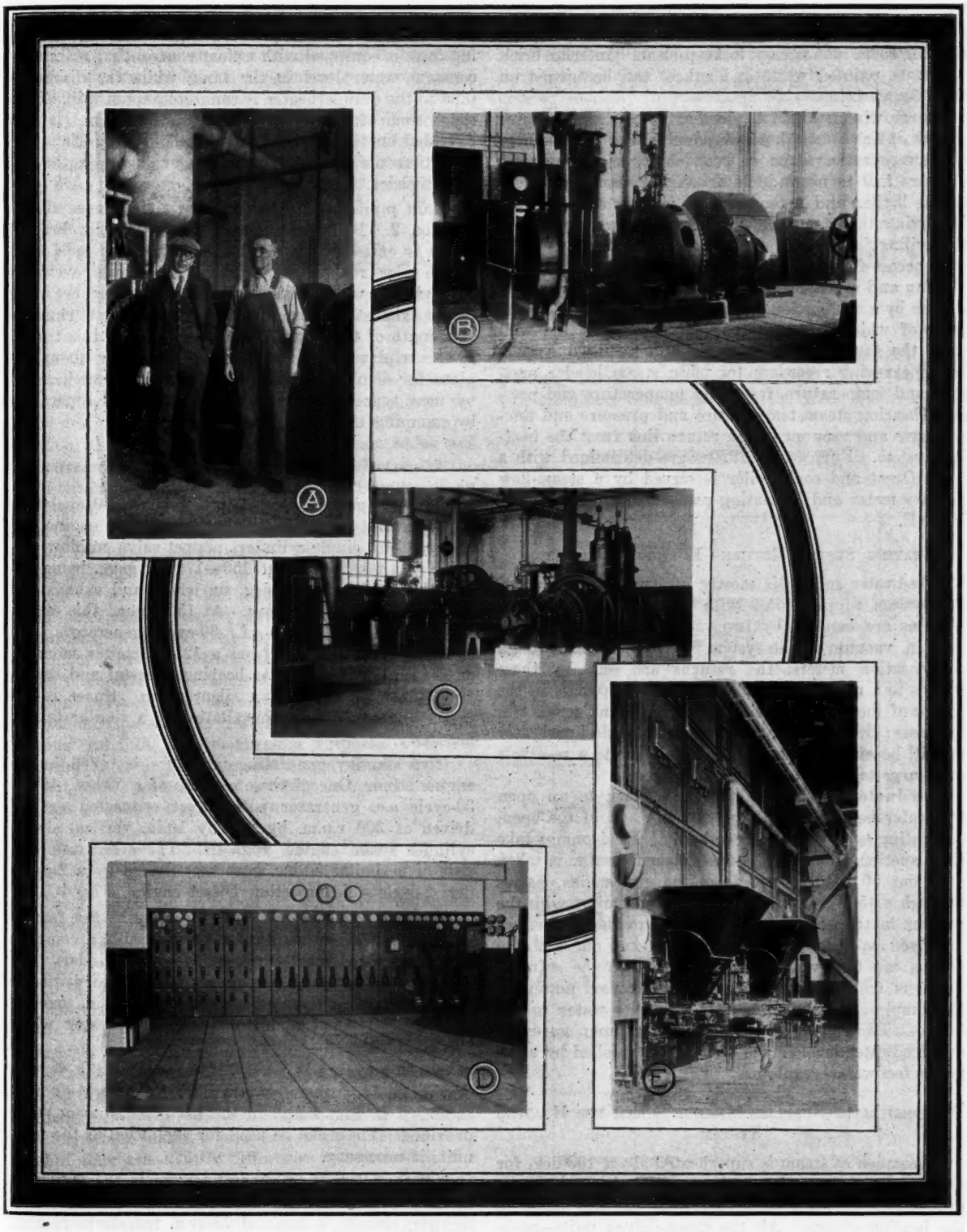


FIG. 4. IN ADDITION TO ITS PLEASING APPEARANCE, NEW PLANT IS DESIGNED FOR CONVENIENCE AND ECONOMY

A—The men who make the wheels go 'round: left, F. W. Dyer, plant engineer of company, designer; and right, James T. Sullivan, chief operating engineer. B—Standby, 50-kw., 30-cycle generator driven by vertical steam engine. Forced draft fan in background. C—At left is the new 938-c.f.m., steam-driven air compressor; at right, a 50-kw., 30-cycle, standby generating set, driven by a Diesel engine. D—Switchboard carries all necessary meters and switches for control of generating units and feeder circuits. E—Two boilers are fired by single-retort underfeed stokers, with complete combustion control. Space is provided for a third boiler.

for operation and for proper cleaning and adjustment. This arrangement simplifies the boiler room considerably, eliminates necessity for a basement and produces a boiler room that is easy to keep clean. Interior brick walls are painted white and a hose can be turned on them for cleaning.

Large windows on two sides of the boiler room give plenty of light. As these windows reach to the ceiling, they were rather hard to keep clean, as the window cleaners had to use ladders or staging, causing considerable bother and a tendency to neglect the cleaning. To obviate this, a small monorail trolley was run around the ceiling just over the windows, providing quick and easy access for cleaning.

Fan and stoker speeds are adjusted for various conditions by a combustion control system, the master regulator of which is set in the engine room on the wall near the fan. On this wall is also mounted a gage board carrying recorders for main steam header pressure and temperature, feedwater temperature and pressure, heating steam temperature and pressure and temperature and vacuum in the return line from the heating system. Furnace conditions are determined with a hand Orsat and each boiler is served by a steam-flow air-flow meter and indicating pressure and draft gages, Fig. 4E.

Heating System Returns Furnish Feedwater

Feedwater supply is mostly returns from the heating system supplemented with treated makeup water. Returns are handled by two vacuum pumps that keep an 8-in. vacuum in the system. After passing through condensation meters, the returns are sent by these pumps to a receiving tank above the feed pumps in the corner of the engine room, Fig. 2. This tank serves two purposes: first, it supplies water to the desuperheater as will be explained later; second, it forms a reservoir and surge tank in the feedwater system.

Feedwater flows from the tank down to an open feedwater heater of 1000 hp. capacity and of the open, deaerating type with vent condenser. Feed pumps take their suction from this heater. Makeup water is taken at about 50 lb. pressure from the city mains, passes through a 4500-g.p.h. water softener and mixes with the returns in the heater. Suction lines to the pumps are arranged so that the heater can be cut out and the pumps can take water either direct from the softener or direct from the receiving tank. Two feed pumps of the simplex, steam-driven type send the water to the boilers. Each pump is controlled by a pump governor and feedwater level in the boilers is controlled by automatic feedwater regulators.

Desuperheater Supplies Makeup Steam for Heating System

Inasmuch as steam is superheated about 150 deg. for the benefit of the main steam engine, it is necessary to desuperheat it when supplying it as makeup steam to the heating system. All the steam-driven units—main and standby units, feed pumps, air compressor, fan engine—exhaust to a common header at about 1.5 lb. gage pressure; the exhaust pressure from each unit is controlled by an individual back pressure valve. Live steam for makeup goes to this exhaust header first through a reducing valve and then through the desuperheater, Fig. 1. This unit takes water for desuperheating from the receiving tank, noted above. To insure a constant head of water to the desuperheater, the receiving tank is equipped with a float control that maintains constant water level in the tank, while the discharge pipe to the desuperheater is connected about 6 in. above the bottom of the tank. An automatic control is also provided on the desuperheater itself. Connections are such that the open feedwater heater floats on the exhaust header.

Main piping and exhaust connections are as shown on Fig. 2. Boilers are connected to a main header, which is entirely of welded construction. Leads from this header run to the engine-driven units overhead through the wall. Exhaust lines run under the floor to the exhaust header, which goes to a tunnel running the length of the plant. In the entrance to this tunnel is one triplex pump that pumps well water about the plant for drinking water. All steam drips are handled by float type traps and the drips from oil separators by pumping traps.

Uniflow Engine Drives 30-Cycle Generator

Power is generated at 480 v., 3-phase, 30 cycles by the main unit shown in the headpiece. The engine is a 28 by 40-in. single-cylinder, poppet-valve uniflow machine. It takes steam at 150—175 lb. gage, being designed for 170 lb., 100 deg. superheat and exhausts at 1.5 lb. gage as noted above. At 150 r.p.m., this engine drives a 1250-kv.a., 0.8-p.f., 30-cycle generator. Excitation for this comes from a 125-v. exciter mounted on the outboard generator bearing pedestal and driven from the main shaft by a silent chain. Space is left in the engine room for installation of a similar unit if necessary.

Two standby generating units are installed in the engine room. One of these consists of a 50-kw., 480-v., 30-cycle a.c. generator with direct connected exciter, driven at 300 r.p.m. by a 9 by 10-in. vertical single-cylinder steam engine, Fig. 4B. The other unit consists of a similar 50-kw. generator driven by a 2-cylinder, 2-cycle solid injection Diesel engine, Fig. 4C.

For supplying air at 95 lb. pressure to the factory processes, a 938-c.f.m. duplex, horizontal air compressor, driven by cross-compound steam cylinders, was installed. For lower air pressures and quantities, a 430-c.f.m. motor-driven compressor was put in, together with an old 50-c.f.m. motor-driven compressor which was reconditioned.

Direct current is needed for some of the factory driving motors, therefore small motor-generating sets, as shown in Fig. 2 and in the list of equipment, were provided. These can be used for excitation of the main unit, if necessary.

All the alternating current service to the factory is at the generator voltage, 480 v., transmitted direct. For lighting circuits, a bank of 75-kv.a. transformers gives 120 v.

Arrangement of the switchboard, Fig. 4D, is one of the most pleasing features of the engine room. An opening between two pilasters at the side of the room was just right for the board, giving space behind it for wiring, buses and transformers. Above the board was

placed a panel carrying an electric clock, a master steam pressure gage and an air pressure gage. The board consists of one regulator panel with frequency and power factor meters and synchronoscopes, 3 generator panels, 6 feeder panels, 2 motor-generator control panels and 2 lighting feeder panels.

As shown in Figs. 2 and 3, the entire plant is on one level, with no basement except a small one for the vacuum pumps and various traps. This makes for easy observation and accessibility of all piping and equipment. Red brick and steel form the walls, with plenty of windows and good artificial lighting and the plant presents a pleasing, uncrowded appearance.

While complete operating records are not available, it is believed that the new plant will show a high degree of economy in operation. It can be handled conveniently by two operators. It is in direct charge of James T. Sullivan, chief operating engineer, with F. W. Dyer, chief engineer of the company, supervising all generation and distribution of power.

Industrial Wastes Affect Plant Water Supply†

PART II. BOILER FEEDWATER TAKEN FROM POLLUTED STREAM REQUIRED VARIOUS TREATMENTS. BY D. C. CARMICHAEL*

MAKEUP WATER at the power plant discussed in the first part of this article was not as seriously affected by the pollution in No. 1 stream as was the cooling water for the surface condenser. The major source of the makeup water was No. 2 stream which was free of acid and was only occasionally affected by the acid contamination from No. 1 stream. Because of an insufficient volume of water from No. 2 stream, the water from the other stream was approximately 10 per cent of the total makeup water. This small percentage of the makeup water did not allow for any acid to be present on account of the neutralizing effect of No. 2 stream but the permanent hardness, or scale-forming constituent, was increased in the proportion of the amount of acid in No. 1 stream.

This increase in permanent hardness was due to a reaction between the temporary hardness of No. 2 stream and the sulphuric acid of No. 1 stream, thus forming calcium and magnesium sulphate. It was necessary to treat the water with soda ash in order to prevent scale formation and corrosive action due to the presence of magnesium sulphate.

DATA FROM FOUR PLANTS SHOW EFFECT OF POLLUTION ON FEEDWATER

Direct effects of pollution on boiler feedwater are more definitely shown in data collected from four industrial plants using river water. Plants 1, 2 and 3 were using water which was polluted by acid waste but, due to the temporary hardness, the acid was neutralized and converted to calcium sulphate, or permanent hardness. Plant 4 was supplied with feedwater which showed acid at all times, due to the greater number of steel plants being situated on the river above the feedwater intake line.

Plant 1 was equipped with a hot-process lime-soda softener, while plants 2 and 3 used an internal treatment of soda ash. Little difference was noticed in the percentage of calcium sulphate in the scale from any of the three plants, although a decided increase in the amount of sludge in plants 2 and 3 as compared to plant 1 was noticed when the boilers were down for cleaning.

Plant 4 was equipped with an intermittent, cold-process, lime-soda softener. Ferrous (iron) sulphate was used as a coagulant when the river water showed

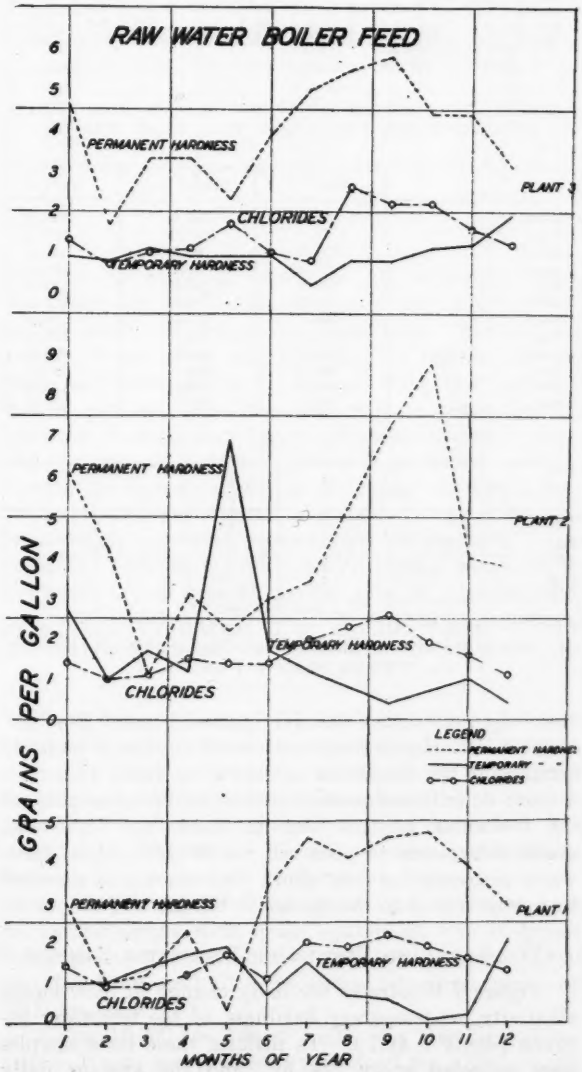


FIG. 6. VARIATION IN HARDNESS AND CHLORIDE CONTENT OF BOILER FEEDWATER FOR THREE POWER PLANTS ON STREAM CONTAINING INDUSTRIAL WASTES, FOR ONE YEAR

†Part I of this article, dealing with effect of river water polluted by industrial wastes on condensers of a steam power station, was published in the July 1, 1928, issue of Power Plant Engineering.

*Cyrus Wm. Rice & Co., Pittsburgh, Pa.

high in suspended matter but, during certain periods of the year, the river water contained enough ferrous sulphate so that no additional quantity was necessary to produce a clear water in the settling or treating tanks.

Inasmuch as plants 1, 2 and 3 were situated on the same river, an excellent comparison of the changes in hardness was obtained. This comparison is plotted in Fig. 6, which shows the variation in hardness and chloride content over a period of a year. The plants

TABLE IV. LABORATORY ANALYSIS OF COMPOSITE MONTHLY SAMPLES OF FEEDWATER FOR PLANTS 1, 2 AND 3

	Plant 1			Plant 2			Plant 3		
				(Grains per U. S. Gallon)					
Month	T.H.*	P.H.‡	Chlorides	T.H.	P.H.	Chlorides	T.H.	P.H.	Chlorides
Jan.	1.0	3.0	1.4	2.7	6.1	1.4	.9	4.6	1.3
Feb.	1.0	1.0	.9	1.0	4.2	1.0	.8	1.7	.7
March	1.4	1.2	.9	1.7	1.1	1.1	1.1	3.3	1.0
April	1.7	2.3	1.2	1.2	3.1	1.6	.9	3.3	1.1
May	1.9	.3	1.7	6.9	2.2	1.4	.9	2.3	1.7
June	.7	3.4	1.1	1.7	3.0	1.4	.9	3.9	1.0
July	1.5	4.6	2.0	1.2	3.4	2.0	.2	5.0	.8
Aug.	.7	4.1	1.9	.8	5.5	2.3	.8	5.5	2.6
Sept.	.8	4.6	2.2	.4	7.3	2.6	.8	5.8	2.2
Oct.	.1	4.7	1.9	.7	8.8	1.9	1.1	4.4	2.2
Nov.	.2	3.9	1.6	1.0	4.0	1.6	1.2	4.4	1.6
Dec.	2.1	2.9	1.3	.4	3.8	1.1	1.4	3.1	1.2

* Temporary Hardness
‡ Permanent Hardness

TABLE V. AMOUNT OF SODA ASH NEEDED FOR TREATMENT, POUNDS PER 100,000 GAL. RAW WATER

Month	Plant 1	Plant 2	Plant 3
Jan.	76.5	150.0	135.0
Feb.	97.0	120.0	132.0
March	100.2	90.0	142.0
April	66.1	80.0	137.0
May	77.0	56.0	132.0
June	94.0	75.0	130.0
July	144.0	80.0	135.0
Aug.	157.0	90.0	132.0
Sept.	184.0	100.0	135.0
Oct.	140.0	135.0	145.0
Nov.	125.0	68.0	140.0
Dec.	99.0	70.0	127.0

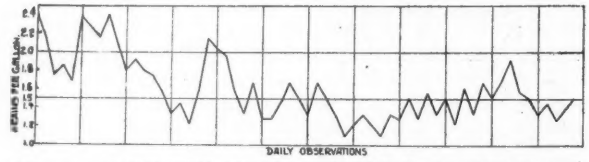


FIG. 7. DAILY CHANGE IN BICARBONATE ALKALINITY OR TEMPORARY HARDNESS OF THE FEEDWATER BETWEEN PLANTS 1 AND 2

were so situated that the river passed Plant 1 first and Plant 3 last. Laboratory analysis of composite monthly samples of the feedwater is shown in Table IV, while a more definite comparison of the changing quality of the feedwater may be seen in Table V. This table shows the amount of soda ash per 100,000 gal. of feedwater necessary for treatment. This amount of chemical was proportional to the change in hardness of the water.

Collection and Testing of Feedwater Samples

Figure 7 illustrates the daily change in bicarbonate alkalinity, or temporary hardness, of the feedwater between plants 1 and 2. In making these tests samples were collected every 2½ hr., and the average daily results plotted. Acid contamination was from a plant above the location at which these samples were collected.

Tests made on samples of water collected at the intake of the river pump from Plant 4 indicated that the feedwater was acid. An average of tests made on samples collected every 3½ hr. over a period of 29 days is shown in Fig. 8. The curve marked "total acidity" is the acid content due to sulphuric acid and ferrous sulphate, while the free acid is that due to sulphuric acid alone. Procedure for making these tests was described in the first part of the article.*

To protect the pipe lines through the plant sufficient lime was fed to neutralize the acid content. This, however, did not decrease the permanent hardness, which is shown in Fig. 9. The temporary hardness and chlorides are also shown in this figure. The temporary hardness did not exist in the river water itself, but was

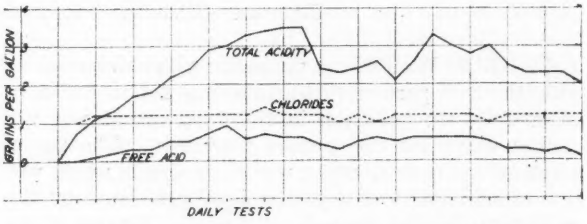


FIG. 8. AVERAGE DAILY TESTS OF RIVER WATER; SAMPLES TAKEN EVERY 3½ HR. FOR 29 DAYS AT INTAKE OF RIVER PUMP, PLANT 4

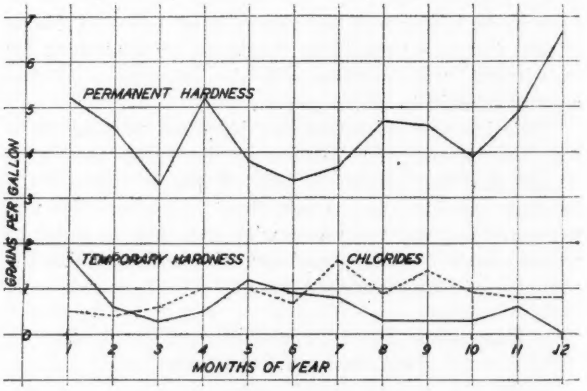


FIG. 9. AVERAGE MONTHLY ANALYSIS OF FEEDWATER, PLANT 4

due to the lime combining with carbon dioxide in the water and, as these samples were collected at the softener house, no acid content was present.

Tables VI and VII are the laboratory analyses of the different samples of water as plotted in Figs. 8 and 9. To give the reader a clearer view of the monthly changes in the feedwater, the chemical requirement per 100,000 gal. of feedwater is given in Table VIII. This illustrates the wide change in hardness, which was largely due to waste acid pollution from different steel plants.

While the acid contamination as just discussed would not appreciably increase the chemical costs of treating

*Attention is called by the author to two slight errors in the factors that appeared on the manuscript of the Detailed Directions for Testing Water Samples appearing in Part I on page 712 of the July 1 issue.

In paragraph 3 of the directions, the last sentence should read: "This reading, times the factor 1.14, gives the total acid in grains per U. S. gallon of sulphuric acid." In paragraph 6, the last sentence should read: "This reading, times the factor 1.16, gives the temporary hardness or methyl orange alkalinity."

water in a small plant having a few hundred boiler horsepower, yet in Plant 4 it was a major item, when taking into account that the average monthly water requirement for boiler feed purposes was 55,000,000 gal. and that the chemical used averaged 27,000 lb. of lime and 90,000 lb. of soda ash.

What Can Be Done to Prevent River Pollution by Discharge of Industrial Waste

On account of the excessive yearly costs resulting from acid wastes into streams, some means should be employed for this waste disposal. The following methods can be used for the complete neutralization of the acid depending on the amount of waste dumped into the stream: 1—treating with lime in separate tanks and disposal of resulting sludge; 2—recovery of ferrous sulphate.

Treating with Lime and Disposal of Resulting Sludge

All the wastes could be pumped to a suitable lime-treating plant and the effluent discharged into the stream. Ground lime rock could be used as the initial treatment and the effluent mixed with a small amount of burnt lime before being discharged to the main stream. This would effect final neutralization in cases where storage tanks were not of sufficient capacity to hold 2 or 3 days' storage of waste.

In order to secure proper mixing before treatment, however, it is advisable to have the storage tanks of such capacity to hold at least 2 days' supply of the waste acid. The sludge could be discharged in suitable low areas or dewatered on beds of sand or other porous material and then removed to a suitable dumping location. The expenditure involved in dewatering and removal of the sludge in addition to the cost of the lime treatment would be large.

TABLE VI. ANALYSIS OF DAILY SAMPLES OF FEEDWATER FOR PLANT 4 AS PLOTTED ON FIGS. 8 AND 9

Observation	Total Acid (Grains per U. S. Gallon)	Free Acid (Grains per U. S. Gallon)	Chlorides (Grains per U. S. Gallon)
1	0.0	0.0	1.0
2	.7	0.0	1.2
3	1.1	0.1	1.2
4	1.3	0.2	1.2
5	1.7	0.3	1.2
6	1.8	0.3	1.2
7	2.2	0.5	1.2
8	2.4	0.5	1.2
9	2.9	0.7	1.2
10	3.0	0.9	1.2
11	3.3	0.5	1.2
12	3.4	0.7	1.4
13	3.5	0.6	1.2
14	3.5	0.6	1.2
15	2.4	0.4	1.2
16	2.3	0.3	1.0
17	2.4	0.5	1.2
18	2.6	0.6	1.0
19	2.1	0.5	1.2
20	2.6	0.6	1.2
21	3.3	0.6	1.2
22	3.0	0.6	1.0
23	2.8	0.6	1.2
24	3.0	0.5	1.2
25	2.5	0.3	1.2
26	2.3	0.3	1.2
27	2.3	0.2	1.2
28	2.3	0.3	1.2
29	2.0	0.1	1.2

TABLE VII. MONTHLY ANALYSIS OF FEEDWATER SAMPLES, PLANT 4, AS PLOTTED ON FIGS. 8 AND 9

Month	Temporary Hardness (Grains per U. S. Gallon)	Permanent Hardness (Grains per U. S. Gallon)	Chlorides (Grains per U. S. Gallon)
Jan.	1.7	5.2	.5
Feb.	.6	4.5	.4
March	.3	3.3	.6
April	.5	5.2	1.0
May	1.2	3.8	1.0
June	.9	3.4	.7
July	.8	3.7	1.6
August	.3	4.7	.9
Sept.	.3	4.6	1.4
Oct.	.3	3.9	.9
Nov.	.6	4.9	.8
Dec.	0	6.7	.8

TABLE VIII. MONTHLY CHEMICAL REQUIREMENTS PER 100,000 GAL. OF FEEDWATER, PLANT 4

Month	Soda Ash	Lime
Jan.	147.8	49.5
Feb.	129.5	38.1
March	150.0	43.4
April	139.5	41.5
May	111.5	32.6
June	148.2	42.2
July	225.0	62.9
August	145.0	39.6
Sept.	181.0	49.0
Oct.	207.7	58.2
Nov.	132.5	38.1
Dec.	138.2	46.8

Recovery of Sulphate of Iron

Inasmuch as acid wastes from pickling tanks contain large amount of dissolved iron in the form of ferrous sulphate, this could be recovered and sold as copperas, or sugar of iron. In this recovery process, the wastes are discharged into lead-lined tanks and the excess water evaporated by steam coils. The concentrated liquor, after sedimentation, is discharged into lead-lined tanks where the ferrous sulphate crystallizes out on cooling. The free acid may be neutralized by addition of scrap iron before evaporation, thus increasing the amount of ferrous sulphate produced and rendering the liquor suitable to discharge into the stream with the addition of small amounts of lime as may be required to neutralize any methyl orange acidity remaining. Although this recovery process may not be profitable at the present market price of iron sulphate, yet in the long run it would be the most economical method of disposal of acid wastes.

Discussing the use of Diesel engines for peak loads, M. Gercke stated before the Diesel Engine Users Association in London that of the total capacity of a central station, some 50 per cent is often required to carry a peak load which lasts for only some 8.5 per cent of the yearly operating time. This 50 per cent of capacity delivers only 4 per cent of the yearly output.

Quick starting for these peak loads was stated to be unsatisfactory with steam equipment, two instances being given where 30 t. of coal were used to carry 12,000 kw. for 4 hr. and 21 t. to carry two short peaks of 6800 kw. each.

Using 10,000-kw. Diesel units, the Hamburg Electricity Works has produced peak load for 0.55 to 0.867 lb. of fuel per kw-hr. or for 1.06 to 1.16 cents per kw-hr. including fuel and capital charges.

Effect of Reheating on Station Economy

DETAILED STUDY OF THE HEAT ECONOMY OF VARIOUS METHODS OF REHEATING FOR A PARTICULAR PLANT[1]. BY A. G. CHRISTIE[2] AND C. C. FRANK[2]

MANY OF THE DISCUSSIONS concerning gains that may be obtained through the application of the reheating cycle as applied to steam turbines have been based on purely thermodynamic considerations, and do not treat with the variables introduced by the different efficiencies in the superheated and the wet regions of the turbines, nor with the changes in condensers and other auxiliary power resulting from changes in the cycle.

To provide means for a correct evaluation of the various methods of reheating for a particular plant and to investigate the comparative value of certain reheating

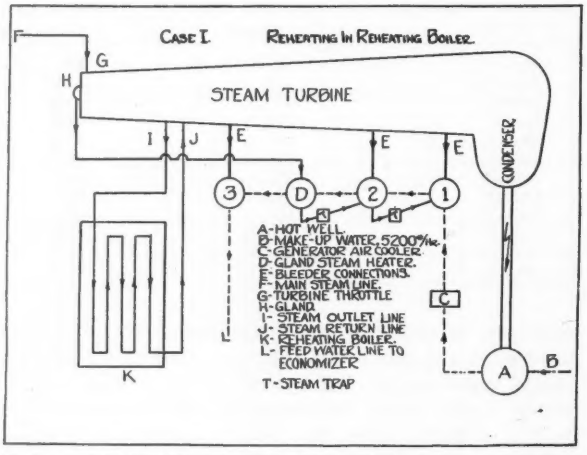


FIG. 1. DIAGRAMMATIC LAYOUT FOR CASE 1, WHERE THE REHEATING IS DONE IN A SEPARATELY FIRED REHEATING BOILER

methods as applied to a specific turbine operating under certain assumed power plant conditions, detailed studies were made for five cases as follows: Case 1—reheating and reheat boiler separately fired, Case 2—reheating by live steam, Case 3—reheating by heat pump, Case 4—direct expansion from 860 deg., Case 5—direct expansion from 725 deg.

Calculations were based on a load of 40,000 kw. carried on a turbine of 45,000 kw. rated capacity operating under the following conditions: Throttle pressure, 550 lb. gage; total steam temperature (except Case 4), 725 deg. F.; inlet pressure to first stage nozzle, 536 lb. abs.; vacuum in condenser, 1 in. of mercury abs.; speed, 1800 r.p.m.

CASE 1, WHEN STEAM IS REHEATED IN A REHEAT BOILER

In Case 1 the steam passes from the high pressure section of the turbine at 120 lb. abs., 424 deg. F. through a reheater in the boiler and is returned to the turbine at 110 lb. abs., 725 deg. F. Under these conditions, steam consumption was assumed to be 7.87 lb. per kw-hr. passing through the throttle, or a total steam admission to the turbine of 314,800 lb. per hr. A makeup of 1.65 per cent and a gland leakage of 1.38 per cent of throttle flow, or 5200 and 4400 lb. per hr. respectively was assumed, which with the generator air cooler was used in the five cases considered in order to simplify the problems.

It was assumed that a feedwater economizer would be used with the boiler and that the feedwater in Case 1 would be heated by bled steam to 210 deg. F. Three bleeder heaters and a heater using gland steam were assumed which, with the generator air cooler, raised the condensate from the hotwell to 210 deg. F. It was assumed in all cases that the discharge from the condensate pumps left the generator air cooler at 80 deg. F.

On the basis of the above assumptions for Case 1 expansion lines were drawn for the steam in the turbine and bleeder points on this line were chosen at the following pressures, corresponding to certain stage pressures in the turbine. Bleeder No. 1, 2.5 lb. abs.; Bleeder No. 2, 9.0 deg.; Bleeder No. 3, 15.2 lb. abs.

These same pressures at the various bleeder points were assumed for all the other cases, regardless of the change in heat content of the bled steam in the various set-ups. This was done so that the temperatures of the feedwater leaving each heater remained constant in all cases, making the results more comparable. The first and third bleeder heaters were of the open type, while a closed heater was used for the second bleeder heater. The choice of these types of heaters had no influence on the study of the reheating cycle.

Total heat of the gland steam was assumed to be 1315 B.t.u. per lb. for all cases. A closed heater was used for the gland steam and was placed between the second and third bleeder heaters. The drips from the gland steam heater were cascaded through a trap into the second bleeder heater and the drips from this heater were cascaded in turn into the first bleeder heater which is of the open type. The diagrammatic arrangement of the equipment is shown in Fig. 1. For resuperheating, the best point comes at approximately 1/5 to 1/6 of the initial pressure. For Case 1, this was taken at 1/5 of the throttle pressure.

CASE 2 BASED ON LIVE STEAM REHEATERS

Case 2 was based on the assumption that the steam between the high and low-pressure turbine sections was reheated in a live steam reheater by steam taken from the main line just before the throttle valve. The condensate from this reheater, being at throttle pressure, was assumed to contain the heat of the liquid corresponding to throttle pressure. It was delivered to a mixing heater on the main condensate line placed beyond the third bleeder heater. This mixing raised the final feedwater temperature above 210 deg. F. The arrangement of equipment is shown in Fig. 2.

When the final feedwater temperature from the mixing heater was above 210 deg. F., it was assumed that the flue gases would leave the economizer at correspond-

[1]From serial report of N. E. L. A. Prime Movers Committee.
[2]Johns Hopkins University.

ingly increased temperatures. To calculate the effect of this rise in flue gas temperature on boiler and economizer efficiency, a certain bituminous coal of 14,000 B.t.u. per lb. was assumed to be burned with 20 per cent excess air. With these assumed conditions, an increase of 40 deg. F. in flue gas temperature would represent 1 per cent of the heating value of the fuel and would correspond to a reduction of 1 point in boiler and economizer efficiency. As a basis for comparison of the various cases considered, it was assumed that the boiler and economizer efficiency in Case 1 was 87 per cent at 210 deg. F. and corrections necessary due to increased feedwater temperature were made to this efficiency, assuming a straight-line decrease in efficiency from 87 per cent at 210 deg. F. to 86 per cent at 250 deg. F.

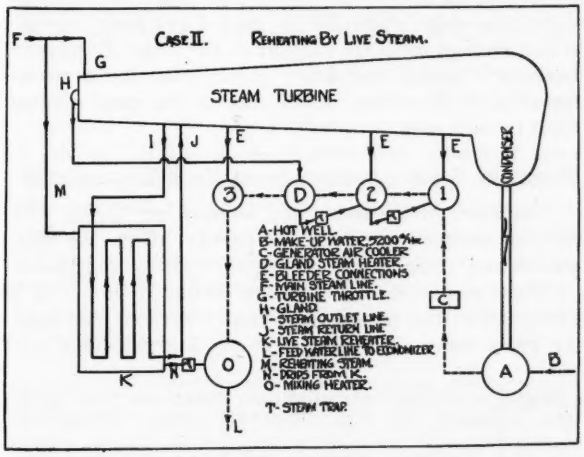


FIG. 2. DIAGRAMMATIC LAYOUT FOR CASE 2, WHERE REHEATING IS DONE BY LIVE STEAM

In all cases where the reheating principle was applied, the pressure drop was allowed for losses in the reheater and piping as follows.

Pressure of steam at extraction per sq. in. abs.	Pressure drop lb. per sq. in.	Pressure of steam on readmission to turbine, lb. per sq. in. abs.
120	10	110
88	8	80
65	6	59
36	3	33
26	2	24
20	2	18

Best Reheat Pressure for Reheating Lower When Live Steam Heaters Are Used

It is reasonable to expect that the pressure at which reheating by live steam gives the highest economy would be less than the pressure giving highest economy when reheating is done in the boiler. The reason for this will be apparent with the consideration of the possible reheating temperature in the two cases. When reheating in the boiler, the steam can be raised to 725 deg. F. but when reheating by live steam at throttle pressure, the maximum temperature the steam can reach, assuming 10 deg. F. thermal difference in the reheater, would be the saturation temperature of the live steam at 550 lb. absolute, that is 480 deg. F. less 10 deg. F., or 470 deg. F. This lower reheat temperature would be more effective in the low-pressure section of the turbine, when a lower reheat pressure than that used in Case 1 is employed. In order to determine the most economical reheating pressure in Case 2, 120, 88, 65, 36, 26 and 20 lb. absolute were assumed and detailed calculations made.

Limiting reheat temperature of the steam in Case 2 has been assumed not to exceed 470 deg. If the initial pressure of the reheating steam could be raised, the saturation temperature would also rise and a limiting reheat temperature would be increased. Reference has been made from time to time to the application abroad of the heat pump as a device to raise the pressure of steam. It is reliably reported that a compression efficiency of 60 per cent can be effected with heat pumps of the size here considered.

Case 3 Considers the Use of a Heat Pump

This heat pump has been applied in Case 3 in the following manner, using the equipment as represented diagrammatically in Fig. 3: The steam to be reheated is first passed through a live steam reheater, as in Case 2, and resuperheated to the same temperature, that is,

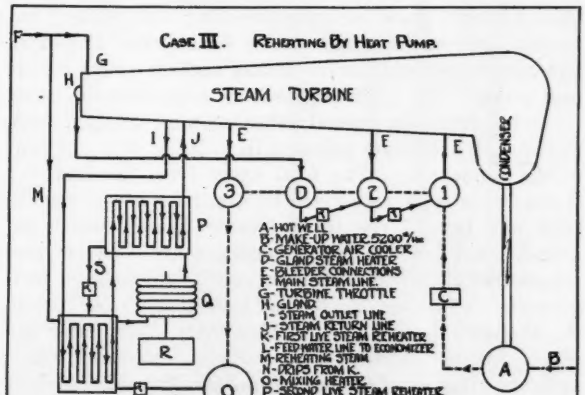


FIG. 3. DIAGRAMMATIC LAYOUT FOR CASE 3, WHERE HEAT PUMP IS USED FOR REHEATING PROCESS

470 deg. F. This is done by live steam taken from the main steam line just before the throttle valve. The heat pump suction takes dry saturated steam at a pressure of 550 lb. absolute from the first live steam reheater and compresses it to 1540 lb. absolute, at which pressure it is delivered to the second reheater.

All heat losses in pumping were added to the adiabatic work of compression to 1540 lb. and gave the total heat of the steam supplied to the second large steam reheater as 1386 B.t.u. per lb. A radiation loss of 6.3 B.t.u. was allowed, making the heat content of the reheating steam 1380 B.t.u. per lb. The steam from the turbine, which is reheated in the first live steam reheater to 470 deg. F., passes through the second reheater where its total temperature is further increased to the saturation corresponding to 1540 lb. absolute or 600 deg. F. less a terminal difference of 10 deg. F.

This steam at 590 deg. F. then re-enters the low

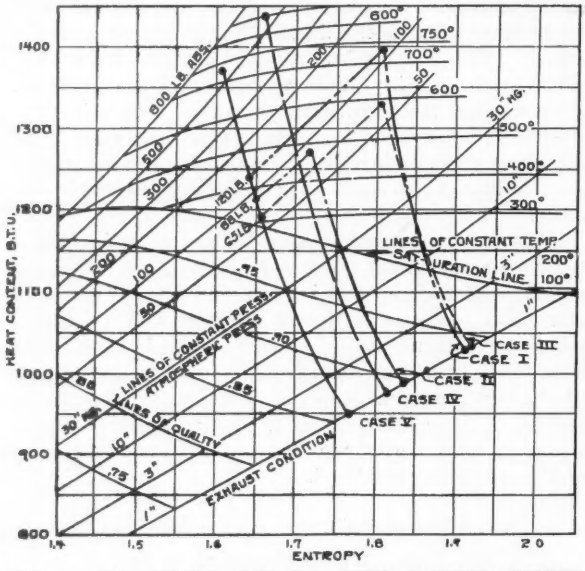


FIG. 4. EXPANSION LINE FOR THE VARIOUS CYCLES SUPERIMPOSED ON A MOLLIER DIAGRAM

pressure portion of the turbine. The resuperheat temperature is thus increased 120 deg. F. over the temperature in Case 2. On the face of this increased superheat, Case 3 should show increased economy over Case 2 but against this saving, there must be charged the extra live steam required for reheating and the work of the heat pump. The latter proves to be a considerable item.

Drips from the second reheater were trapped back to the first live steam reheater in order to save the heat of the condensate. The total drips from the first live steam reheater were carried to a mixing heater on the feed line beyond the third bleeder heater, which increased the final feedwater temperature. Boiler and economizer efficiencies were corrected for increased temperature as in Case 2. Reheat pressures of 120, 65, 36 lb. absolute leaving the turbine were taken and the plant economy calculated in order to determine which pressure gives greatest gain from reheating when a heat pump is employed as outlined above.

Cases 4 and 5 Consider Only Direct Expansion from 860 and 725 Deg. F.

Case 4 was calculated with no reheat but with an initial steam temperature of 860 deg. F. The results from this calculation are of particular interest as compared with those of the other cases considered. Case 5 was calculated with the initial steam conditions of Case 1, 2 and 3, that is, 560 lb. gage, 725 deg. F. with no reheat, to form a base with which to compare all data. The plant arrangement in both Cases 4 and 5 was assumed as in Case 1, but with no reheater or reheater piping.

Assumed conditions for the 5 cases are superimposed on a Mollier diagram, Fig. 4, and are calculated with allowances for the varying stage efficiency of the saturated region. This variation of efficiency is based on tests which show that the corrections for moisture in the saturated region are about 1.15 per cent decrease in turbine stage efficiency for each 1 per cent increase in the average moisture content in the stage. Expansion lines for Cases 3 and 4 are shown only for a reheat factor of 65 lb. which comes near to the most efficient point in each case.

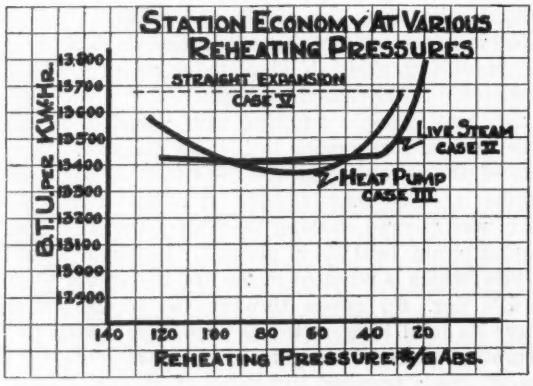


FIG. 5. CURVE SHOWING THE EFFECT OF VARIATION IN REHEAT PRESSURE

Summary Shows Advantage of High Temperature

Variation in the losses and in auxiliary power with various assumed conditions seriously affect the final results and these variations were carefully considered.

Final results for all cases are tabulated in the table which shows the pounds of steam generated per hour, the gross water rate, the B.t.u. per kilowatt-hour, and the increased efficiency over Case 5. Figure 5 shows the B.t.u. per kilowatt-hour with various reheating pressures for Cases 2 and 3. The best economy in Case 2 appears to be with a reheating pressure of between 88 and 120 lb. abs., although there is little variation from 36 to 120 lb. abs. In other words, the overall plant economy seems to be nearly constant with a ratio of reheating pressures at throttle pressure varying from 1/6 to 1/10.

SUMMARY OF THE CALCULATIONS SHOWING THE THERMAL ECONOMY OF THE SEVERAL CASES CONSIDERED

	Lb. steam generated per hr.	Gross water rate with bleeding in lb. per kw. hr.	B.t.u. per net kw. hr.	Per cent gain over Case 5
Case 1	320,000	8.058	12,448	8.69
Case 2 Reheating by live steam at				
120 lb.	328,960	9.826	13,418	1.89
88 lb.	337,735	9.862	13,416	1.91
65 lb.	345,665	9.908	13,428	1.82
36 lb.	359,620	9.965	13,434	1.78
26 lb.	366,500	10.094	13,568	0.80
20 lb.	372,000	10.250	13,754	-0.56
Case 3 Reheating at				
120 lb.	345,190	9.982	13,537	1.02
65 lb.	361,230	9.923	13,366	2.27
36 lb.	376,115	10.107	13,540	1.00
Case 4	320,000	8.626	12,843	8.30
Case 5	320,000	9.973	13,677	0.00

In Case 3, the best economy is with a reheating pressure of 65 lb. abs. and this maximum appears to be well defined. Hence, for 1540 lb. abs. pressure in the second live steam reheater, the ratio of reheating pressure and throttle pressure for best economy appears to be about 1/10.

In Case 2, the degree of reheat is limited by the saturation temperature of the steam at throttle pressure, while in Case 3 it is the limit of the saturation temperature corresponding to 1540 lb. abs. This is not necessarily the limit of the heat pump, and a pressure higher than 1540 lb. abs. might have been chosen.

Case 1, with the reheating boiler, shows the most economical performance when auxiliaries are included.

With the reheating boilers in Case 1, 12,488 B.t.u. per kw-hr. are required. Case 4, without reheat, with 850 deg. F. initial steam temperature, needs 12,543 B.t.u. per kw-hr. The performance would be essentially the same if the initial temperature in Case 4 were increased from 850 deg. F. to 860 deg. F. Case 4 would obviously involve a simpler plant layout than Case 1, as no reheating piping or boilers would be necessary, although higher priced elements would be needed in the superheater.

From the table, it will be apparent that the capacity of the auxiliaries that will be greater in Case 1 than in Case 4. From a heat balance standpoint, there appears to be little difference between the two cases. No attempt has been made to compare the first cost of plant in the various cases, nor to calculate operating costs.

Reheating in the boiler, as in Case 1, shows a gain of 8.69 per cent over no reheating. Reheating by live steam at throttle pressure as in Case 2 shows a maximum gain of only 1.91 per cent, which is less than that frequently assumed for this type of reheating. Case 3 shows slightly more gain than Case 2, but is complicated and made more expensive by the use of the heat pump in the second live steam reheater.

Awards Improve Appearance of Utility Property

Pacific Gas & Electric Co. Gives All Properties an Opportunity to Win Prizes for Good Housekeeping

AMONG BOTH public utility and industrial companies, the importance of well kept and carefully designed buildings and grounds is being recognized and given the attention it warrants. On the Pacific coast, the Pacific Gas & Electric Co. has instituted a merit plan and system of award for encouraging good housekeeping throughout its various properties and according to their house organ, the Pacific Service Magazine, these awards have been responsible for a marked improvement during the past year, many properties now having lawns, grass, vines and flowers that would do credit to the average private home. From the reaction of the employes, it seems as though they had always been interested in doing these things and needed only the official sanction to put their ideas into operation.

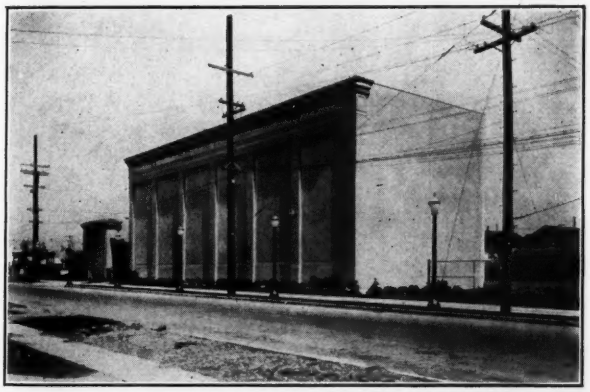


FIG. 1. SUBSTATION I AT OAKLAND WHICH RECEIVED THE HIGHEST RATING OF ANY PROPERTY

Plan Is to Give All Properties an Equal Chance to Win

Awards are made to the properties receiving the highest rating in each plant and to those most presentable, regardless of plant. In the electric department the award consists of bronze plaques for display inside the buildings and larger easel mounted signs for display out of doors, gas department properties receive certificates signed by officials of the company and the office buildings awards are in the form of a gold leaf window transfer, indicative of the rank received.

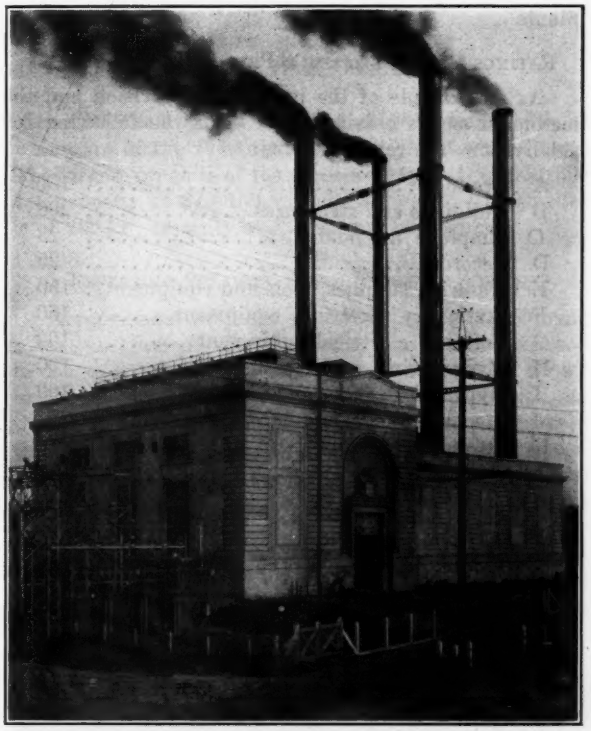


FIG. 2. STATION B AT SACRAMENTO RECEIVED THE HIGHEST AWARD AMONG STEAM STATIONS

A fair system of inspection and rating is difficult. The present scheme attempts to remove the personal element in rating as much as possible, and instructions given to the committee attempt to point out an attitude which will give all the properties a fair chance of winning. A portion of these instructions follows:

"The age, obsolescence and relative importance and capacity of the properties are not to be considered as factors in establishing the rating, emphasis being placed on such conditions as are under the control and

dependent upon the efforts of the attendants. Care should be taken not to deduct merits on account of temporary conditions due to construction or experimental work conducted by parties not under the control of the attendants. Deductions should not be made for temporary conditions due to cleaning or repairs where sufficient time has not elapsed for their removal. Due consideration should be given to operating conditions at the time of inspection. In many plants there are periods in the day's work during which dirt may accumulate but it is removed in regular sequence in the day's routine; however, where there is evidence that such accumulations have remained an unreasonable time, deductions should be made."

Under the present plan, properties under the department of electrical construction and operation are divided into three classes, electric substations, steam stations and hydro plants. During the year 1927, Substation I, in Oakland, shown in Fig. 1, received the first award and the highest rating of any property visited. Station B at Sacramento, shown in Fig. 2, received first prize among the steam-electric stations, and the South Power House at Battle Creek, shown in Fig. 3, received first award among the hydro-electric plants.

Ratings Are Based on a Prearranged Schedule

As an example of the property subdivision and the maximum merits obtainable for each, the following for subdivisions are representative:

A	Grounds	150
B	Buildings and structures	200
C	Employe attendants	25
D	Records	25
E	Material, supplies, tools and equipment	150
F	Stationary electrical equipment	150
G	Rotating electrical equipment	100
H	Hydro prime mover equipment	150
I	Hydraulic structures and equipment	100
J	Steam prime mover equipment	150
K	Steam boiler equipment	100

Each subdivision is then divided into smaller units according to the following typical arrangement:

Subdivision B: Building

Roof, walls, floors, doors, etc., in repairs	15
Fittings, plumbing, etc., in repair	15
Wiring tightly placed and permanent	10
Surfaces painted	20
Painted surfaces not worn or marred	30
Black surfaces polished	10
Floors, walls and ceiling no dust, dirt or marking	20
Windows clean and unbroken	40
Screens not broken or rusty	10
Lamps and fixtures clean and unbroken	20
Miscellaneous	10

Cooperation of Entire Organization Necessary for Success

To reach a high degree of excellence under these ratings schedules necessitates not only more than ordinary care on the part of the attendants, but also more than a passing interest on the part of the local management. There must be judicious use of money, as there must be paint, polish, rags, packing, tools, shrubs, flowers and trees, and there must occasionally be extra help for the disposal of rubbish, leveling of ground and similar work.

Co-operation of construction crews in making neat and attractive installations and the prompt removal of excess material or debris is of considerable importance. Only the management can control this through its supervision and direction. Thus, while good housekeeping is usually laid to the door of the operating employe, first prizes are obtainable only through co-operation and active interest all along the line.

Such success as was achieved during the past year demonstrates that co-operation can be secured and

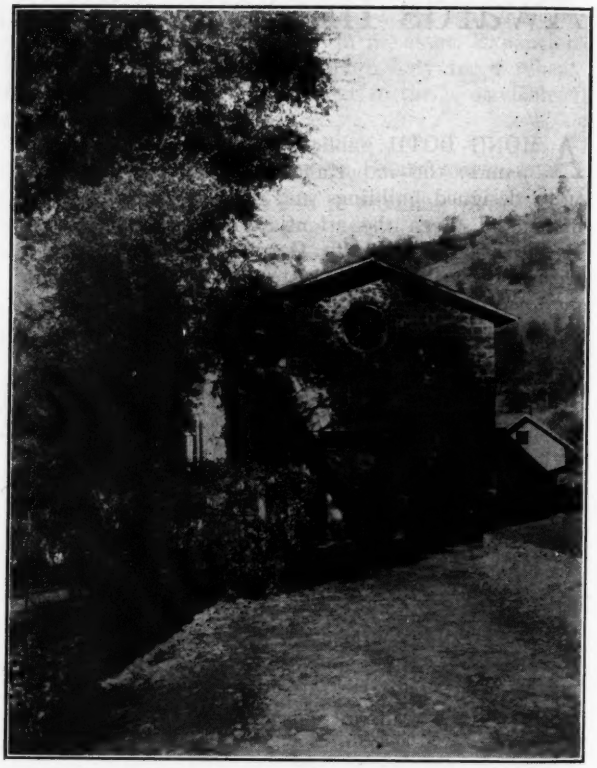
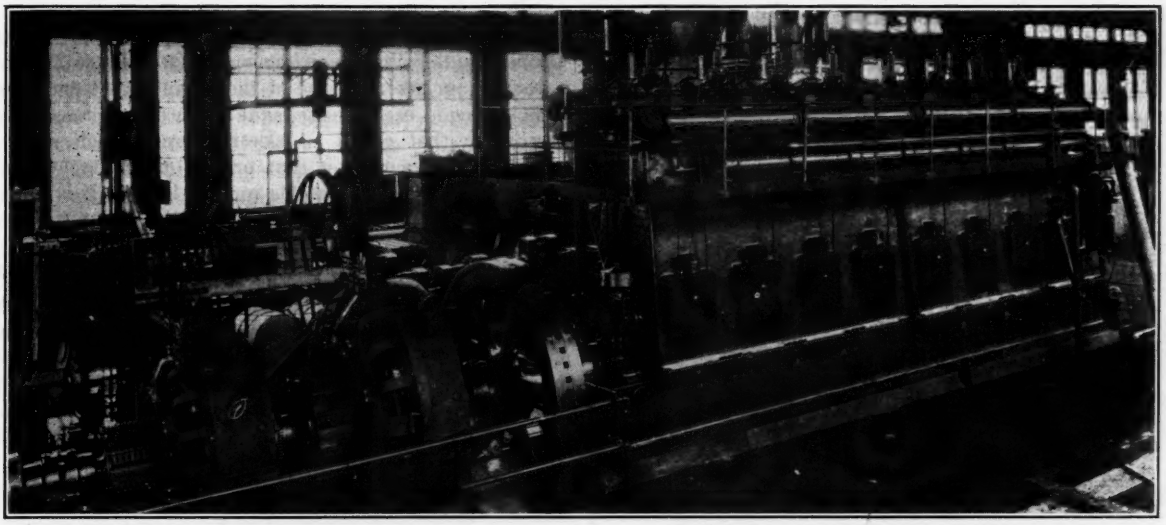


FIG. 3. FIRST AWARD FOR HYDRO STATIONS WENT TO THIS ATTRACTIVE PLANT, THE SOUTH POWER HOUSE ON SOUTH BATTLE CREEK

those who have made the effort are well satisfied with the results. As always, further improvements are possible and present indications are that competition during the present year will be keener than during the past. The object, of course, is, first, working conditions are better because an orderly and clean plant is a safer and healthier place in which to work; second, property of good appearance is an expression not only of pride in itself, but also of good will from the community in which it is located.

Mechanical stokers sold during May, 1928, according to the latest report of the Department of Commerce, reached a total of 130 stokers sold by 12 establishments, installed under 38,705 hp. of boilers. Of this number, 43 were under 6423 hp. of fire tube boilers and 87 under 32,282 hp. of water tube boilers.



Fulton Diesel Engine Stands Exacting Test

WATER-RHEOSTATS, TACHOGRAPH AND TORSIOGRAPH ARE USED IN TESTING FOUR 911-HP. DIESEL ENGINES FOR PANAMA CANAL DREDGES. BY H. F. BIRNIE

UNUSUAL REQUIREMENTS demanded by the purchaser of four 8-cylinder Fulton-Diesels necessitated considerable refinement of test, hence all four engines were tested in the shops of the manufacturer under the supervision and control of the purchaser. The unusual feature of the test was that the engines had to be tested with their generators in place, the power delivered by the engines being measured by the electric current generated in the electric units.

WATER RHEOSTATS USED FOR ELECTRICAL LOAD

Usually a Froude water-brake is used when testing Diesel engines; the arrangement proposed by the purchaser brought about the installation of water-rheostats to dissipate the generated electric current. Furthermore a number of requirements were specified by the purchaser, the principal ones, referring to the testing, being as follows: The cooling water for the engine must have a temperature of 90 deg. at the inlet; the engine was to be subjected to a 48-hr. continuous full load test; the engine builder was to guarantee the engine against critical, torsional or any other form of vibration between the limits of 70 per cent and 120 per cent of the standard full load speed, both on block test and after installation on the dredge; the governor of the engine was to be capable of maintaining the speed of the engine within 5 per cent of the normal in passing from no load to full load, or vice versa.

These conditions called for special testing arrangements, as the testing of standard engines is naturally reduced to what is strictly necessary mainly consisting in checking the good working order of all running parts. The engine, which is of the 4-cycle, single-acting type with 17½ by 24½ in. cylinders, has a mean effective pressure of about 75 lb. per sq. in. at full load and delivers 911 br.hp. at 204 r.p.m. It is coupled to an extension shaft which carries two generators, both of which are of the Westinghouse, d.c., shunt-wound type. The larger, which is of the three-wire type, is of 550/305 kw. capacity at 270/150 v. and 2040 amp. The smaller is of 220 kw. capacity at 120 v. and 1835 amp.

REVERSING POLARITY SAVES RHEOSTAT PLATES

Arrangement of panel is shown in Fig. 1. During a test, instruments for measuring the power absorbed in the water rheostats, were placed on the table shown in the center of the photograph. In open position, on the switchboard below the circuit breakers, will be seen the two field switches and piping which brings the cooling water to the troughs of the water rheostats. The latter are provided with steel plates, which in order to raise or lower them in separate water troughs, are attached to tackles. The plates are connected in such a way that their polarity can be reversed, after a period of operation, so as to counteract, partially, the deterioration of the positive plates.

FIG. 1. WATER RHEOSTATS ABSORB ELECTRICAL ENERGY GENERATED

During the 48-hr. full load test run, a close check was kept on all the temperatures. Thermometers were placed on all cooling water inlets and outlets and on the lubricating oil line. Pressure gages were placed on the cooling water and lubricating oil systems and pyrometers were set in the different exhaust elbows and in the exhaust header. Indicator cards were taken of the pressure in the working cylinders of the compressor and even of the pressure in the exhaust header; the r.p.m. were doubly checked by means of an electric tachometer as well as by a revolution counter driven by the camshaft; the fuel oil was weighed continuously by means of two tanks placed on scales, the oil temperature being recorded; a Klaxon horn was employed to sound the periodical observation intervals.

Previous to the full load run, two other tests had been made, namely the checking of the shaft vibrations by means of the torsiograph and the checking of speed variations of the engine between full load and no load by means of the tachograph.

Critical vibrations in the crank and extension shaft unit, when present, can sometimes be corrected by shortening the extension shaft and shifting the flywheel and generators that are attached. Should this method fail, the only means to correct these critical vibrations is to increase or decrease the shaft diameter; in other words, corrective means are limited and always expensive.

Correction of Speed Variations

Speed variations of the engine between extreme loads, on the other hand, are more easily corrected, when excessive, provided the construction of the fuel pump and fuel injection system is correct. An excessive variation can be corrected by a careful dampening of the movement of the governor sleeve by means of a governor dashpot, provided the engine flywheel is not too heavy, that is, by preventing the governor from reacting too quickly. Another way is to use a more powerful governor, the latter usually being manufactured by a special concern and the original sizes recommended by them to the Diesel engine builder being often a trifle too small.

Torsiographs and tachographs are both driven through pulleys by the extension shaft. Figure 2 shows a tachogram taken on one of the engines, at time intervals, 1 second each, being made by means of a seconds-pendulum that closes an electric circuit each second, which acts on a pointer that presses on the tachogram. This pendulum is not visible in Fig. 1, since it is at the extreme left of the switchboard panel.

Cooling Water Temperature Maintained Constant

One special arrangement had yet to be made to meet the desiderata of the purchaser, namely to keep the cooling water inlet temperature at 90 deg. F. This was accomplished in the manner indicated in Fig. 3. In the Fulton engine, the cooling water enters the compressor low-stage cooling space, escapes through the high-stage water compartment, thence goes to the engine frame and to the cylinder heads, flowing from them to the water-cooled exhaust header. The warm water coming from the exhaust header flows into a tank, as shown diagrammatically in Fig. 3, and is pumped back to the compressor jackets. A connection to the city main permits adding necessary cold water to maintain the temperature at a predetermined degree. Of course, the engine has to run for a certain length of time at a given load before the water reaches a constant temperature.

The most important result of a commercial test on a Diesel engine is the fuel consumption, which is given in pounds of fuel-oil consumed per hp.-hr. With water rheostats, the power generated by the Diesel engine is read off the electric instruments and the corrections for generator losses are computed directly from the chart given by the manufacturer. The r.p.m. reading is unnecessary, except when the indicated horsepower is to be figured. When testing the Diesel with a water brake, the r.p.m. reading is, however, essential to figure the power destroyed in the brake.

During the 48-hr. continuous run, the results of fuel consumption were computed every hour, i. e., the weight

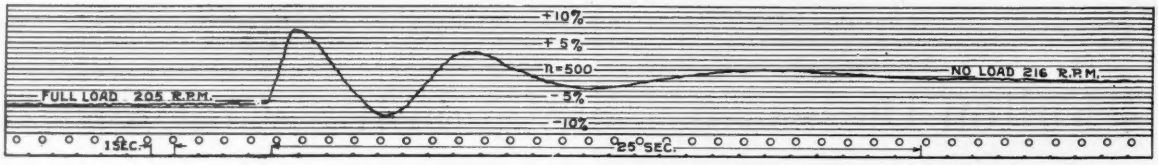


FIG. 2. TACHOGRAM SHOWS VARIATION IN SPEED CAUSED BY SUDDEN APPLICATION OF FULL LOAD OR SUDDEN RELEASE OF SUCH LOAD

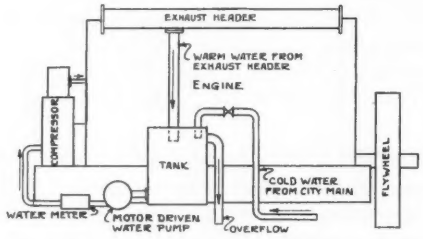


FIG. 3. COOLING WATER SYSTEM PRODUCES PROGRESSIVE REDUCTION OF TEMPERATURE IN THE VARIOUS PARTS OF THE SYSTEM

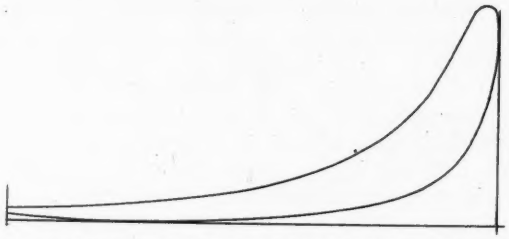


FIG. 4. INDICATOR CARD TAKEN UNDER FULL LOAD FROM ONE OF THE CYLINDERS SHOWS EXCELLENT ADJUSTMENT

of the consumed fuel oil together with the average hourly output of the generators plus the corrections, gave the hourly fuel consumption per brake horsepower hour. Besides these readings, record was kept of the pressures in the three compressor stages; of the exhaust temperatures of each cylinder; of the r.p.m. (double check); of the lubricating oil pressure and temperatures at the outlet from the engine and at the inlet of the oil pump; of the cooling water temperatures at the inlet of the engine, at the outlet of the exhaust header and at each cylinder head; of the cooling water pressure and consumption; of the room temperature and air inlet temperature in the air intake header; and also, indicator cards were taken from all the power cylinders each hour.

Maladjustments Detected by Abnormality

All these readings, except the generator output and fuel weights, can be considered as secondary. They are, however, useful, as abnormal running conditions would soon be detected. For instance, a sudden rise of pressure in the compressor low stages would indicate a leaky intake valve of the high stage; a sudden pressure drop of the compressor high stage would point to a leaky fuel valve; an increase of a cylinder exhaust temperature would point to a defect of one of the fuel pumps and a sudden drop of the r.p.m. would indicate abnormal friction such as of the power pistons due to failure of the cylinder lubricating pump.

These elaborate tests are noteworthy because of the comparatively small size of the engines. Stationary engines of such powers are usually tested less carefully. The tests are also noteworthy because they express the willingness of the modern manufacturer to guarantee fully his product.

There seems to be no advantage for the consumer in testing a Diesel engine with the electric equipment in place, when capacity and fuel economy alone are sought, as the readings of a modern Froude water brake are accurate; but when it is wished to check freedom from torsional vibration and the variation of revolutions per minute between extreme loads, this arrangement becomes essential.

Test Shows Low Fuel Consumption

Fuel consumption of not more than 0.42 lb. per br. hp-hr. was guaranteed by the builder. This was fully met by all of the engines, the first having been run-in longer than the rest, operating with the highest economy.

Determining Fusion Temperatures of Materials

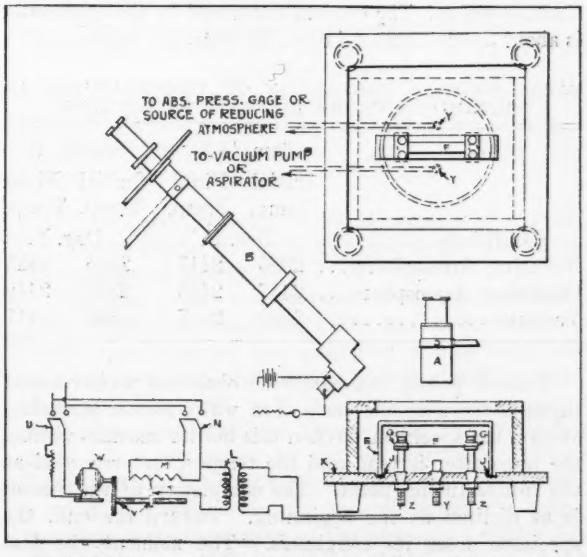
Electrical Method Offers Many Advantages Over Cone Method of Temperature Determinations and Saves Much Time

BECAUSE OF the many inconveniences and difficulties encountered in the determination of the fusing temperature of coal, ash and other materials in the usual type of gas furnaces, an electrical method that has been developed and used in routine work for over a year in the testing laboratories of the Public Service Gas & Electric Co. is described by the N. E. L. A. The arrangement of the apparatus is shown in the accompanying illustration together with a diagram of the electrical connections.

This equipment consists of a strip of metal, F, of high melting point (platinum or tantalum) held in a horizontal position between two clamps, GG′, fastened to two rods, ZZ′, on suitable metal of good conductivity such as brass. The two rods are sealed hermetically in an insulating base, K, of bakelite. A chamber E of pyrex glass is placed over the electrodes, ZZ′, and fitted into a recess in the base provided with a rubber gasket. For usual test conditions under vacuum, it is not necessary to clamp the rubber gasket down as atmospheric pressure is sufficient to insure a tight joint.

Tubes YY′ used to control the atmospheric conditions under the glass cover during a test are hermetically sealed into the base. By this means, either an oxidizing or reducing atmosphere or any degree of vacuum required may be maintained. If the tantalum strip is used instead of platinum it is essential to maintain full vacuum as the tantalum burns in oxygen. Material to be tested is placed on strip F.

Electrodes ZZ′ are connected to the secondary side of the suitable transformer L, of which one side of the primary is connected direct to a suitable source of alternating current and the other side to the slide H of a suitable resistor in series with the circuit. The slide, H, is moved over the resistance coil, M, by means of suitable gears driven by a small universal motor, W.



ELECTRICAL APPARATUS FOR DETERMINING THE FUSION TEMPERATURE OF MATERIALS

Advantages of this current control are: the current through the resistance M on the primary side is small, the change in current flow is uniform giving a uniform increase in temperature through the metal strip, and

all metals placed on the strip F are exposed for the same length of time to the same source of heat, thus making the determinations uniform.

A switch is placed in the circuit of the driving motor W so that the temperature of the strip and the stresses may be maintained constant when the operator is making a temperature reading.

Temperatures Read With an Optical Pyrometer

An optical pyrometer B, preferably of the Wanner type, is placed above the chamber E and focused upon the metal strip F in order to determine the temperature although a thermocouple with its junction brought close to the metal strip and properly calibrated may also be used. A suitable magnifier (30 magnifications produces a large enough image) with an eye piece covered with the blue glass of the polariscope tube to protect the eye of the observer, is placed above the chamber E and focused upon the specimen placed on the metal strip in order to observe the melting or fusing point.

To exclude light as much as possible, the fusion apparatus proper is placed in the box of which the base of the apparatus forms the bottom with a slot in the cover large enough to focus the pyrometer and magnifier on the metal strip and specimen. The specimen should be placed in direct contact with the strip or serious error may be made, due to poor contact, radiation, etc., from the container.

One of the tubes, YY', is connected to a small vacuum pump and the other connected to a gage to note the pressure inside of chamber E, or one tube may be connected to an aspirator bottle and the other to a funnel over a gas burner to collect the products of combustion, passing them through the chamber, E, to make the atmosphere reducing. Speed of the motor W is regulated by means of a resistance X so that it takes 7 min. for the slider to travel the length of the resistance coil M. The current consumed by the apparatus is about 300 w. from a 110-v., 60-cycle, a.c. source.

TABLE SHOWING COMPARISON OF TEMPERATURES AS DETERMINED UNDER DIFFERENT CONDITIONS

	Sample A		Sample B	
	Initial Temp.	Final Temp.	Initial Temp.	Final Temp.
Conditions	Deg. F.		Deg. F.	
Reducing Atmosphere....	2385	2417	2385	2425
Oxidizing Atmosphere...	2417	2453	2397	2440
Vacuum	2385	2397	2385	2417

Fusion points can easily be observed when viewed through the magnifier as a thin white border stretched around the specimen. When this border becomes visible, the pyrometer is read and the temperature recorded as the initial fusing point. The completion of the fusion is as distinct as the beginning. Toward the end, the specimen loses its roughness. The moment the last rough and somewhat darker spots disappear, the specimen is fused completely and the pyrometer reading is recorded as the final fusing temperature. Numerous check tests have been made by different observers and the melting point of metals determined with excellent results. The difference between two determinations, usually within the limits of the pyrometer used, averages 12 or 13 deg. F. The pyrometer must frequently be calibrated. This can be done by means of an acetate lamp or by using a segment of pure copper which melts at 1083 deg. C.

Only About 10 Min. Required for Determination

In making determinations from coal ash samples, the ash obtained from either a 1-gram or a 0.2-gram sample used for a proximate or an ultimate analysis may be used. The ash thus obtained is placed in a small mortar with one or two drops of water and rubbed with an agate pestle to break up any coarse particles. The mortar and its contents are dried. The material in the mortar is then loosened by rubbing and placed on the metal strip. Only about 10 min. are required here for determining its fusing temperature determination as compared with 2 or 3 hr. for the cone method.

Cost of the platinum is small as the actual cost per strip is about 10c and it is good for many determinations. The used material is sold for scrap. In general, all determinations are carried out under a vacuum, this being more easily controlled than standard conditions. In the table is given a comparison of temperatures as determined under different conditions. It is believed that this method is far simpler than the present cumbersome cone method, more accurate and that its use makes study of the probable behavior of the different kinds of fuel under conditions which may exist in the actual furnace much easier.

Safety Record Is Noteworthy

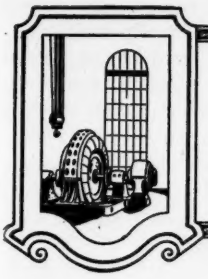
Men of the Amsterdam Steam Station of the New York Power & Light Corp. have made a safety record eclipsing like performance in the entire organization and probably comparing favorably with similar records anywhere. It is 423,095 man-hours without a lost-time accident.

This record dates from early in August, 1925, to May 31, 1928, covering 1004 days, during which period from 42 to 100 men have been at work. Trivial injuries such as burns, scratches, cuts and bruises have happened but have been treated by first aid so that no absence from work resulted.

Operated as a reserve unit during low river flow or for special conditions, the daily routine of a large number of the station force changes as they are engaged on construction, excavation, maintenance and the like as well as routine operation necessary in an 80,000-hp. plant. This condition rather enhances the possibility of accidents and adds to the credit for the record.

Safe methods of operation have always been given the prominence that they deserve, careful instruction being given each man as to what is expected of him to guard his own and others' safety. Bulletin boards and signs remind him of this. Orderliness and good housekeeping prevail to lend helpful environment. Close supervision and a progressive safety have been important factors in establishing this fine record.

H. J. Scruton, superintendent, attributes the satisfactory accomplishment to the constant vigilance of everybody in the station and to the personal pride of every man in maintaining the safety tradition of the organization.



ELECTRICAL MACHINERY FOR LIGHT AND POWER

Electricity---What It Is and How It Acts*

PART VI. NEUTRALIZATION OF ELECTRIC CHARGES, PROPERTIES OF THE ELECTRIC FIELD, POTENTIAL GRADIENT, PRINCIPLES OF CONDUCTION THROUGH GASES

ONE OF THE fundamental tendencies in nature is the tendency towards equilibrium or the equalization of opposites. This is true particularly with regard to energy. When two bodies of different temperatures are placed together with a conducting medium between, the warmer body becomes cool and the cooler body becomes warm until, finally, both have the same temperature. The excess heat energy of the warm body is given up to the cool body until a condition of equilibrium is obtained. In other words, heat energy seeks a lower level in the same way that water or any body elevated above the earth against the force of gravity seeks a lower level. This flow of heat from a high to a low level is, in fact, merely an infinitesimal decrement in the general lowering of the total heat or energy level of the universe.

Shortly after the establishment of the principle of the conservation of energy in the middle of the last century and the recognition of the fact that all the different forms of energy are mutually convertible, one into another, it was also found that the conversion did not work equally well in both directions. Energy in any form it was found could readily be converted into heat but when heat energy was converted back into other forms there was never quite as much left as there had been originally. Some of the energy remained as heat. Once energy is in the form of heat, it is impossible to get all of it out again. This is purely an empirical fact, for which no theoretical necessity has ever been shown. It forms the basis of the second law of thermodynamics.

THE DEATH OF HEAT

If this law is true, it would seem that the total energy of the universe is gradually being transformed into heat and this heat is gradually seeking a lower level. The energy of the universe is in a continual state of transformation. Whether it be in the formation of new stars or of planets, or in the production of heat underneath our boilers, or in the production of rotating torque in our motors, energy is being transformed, but with each transformation, a little of it appears as heat. This heat tends to seek a lower level.

Unless other factors enter in of which we have no knowledge, therefore, at some time far in the distant future, all of the energy in the universe will have been transformed into heat and this heat will have reached its lowest level. The same temperature will exist everywhere. Clausius calls this final state "Warmetod"

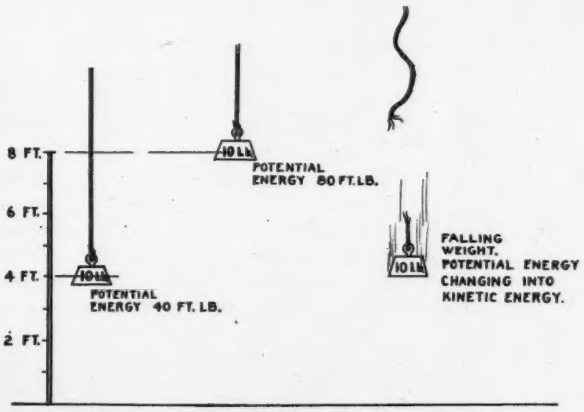


FIG. 1. DIAGRAM SHOWING HOW POTENTIAL ENERGY IS STORED IN A BODY BY VIRTUE OF ITS ELEVATION ABOVE GROUND

A 10-lb. weight raised 4 ft. above the ground has potential energy equal to 10 × 4 or 40 ft. lb. At 8 ft. elevation, its potential energy has doubled. If the weight is permitted to fall, the potential energy stored in it is converted in kinetic energy. The instant it touches the ground, its potential energy is zero but its kinetic energy is a maximum.

(death of heat); and the relentless process of degradation which leads up to it was called by Kelvin the "dissipation of energy."

This idea is not new as pointed out by Paul Healy of the Bureau of Standards.[1] The ancient myths of our Nordic race speak of the coming of a time when both gods and men will sink into an endless, deathless sleep; when upon them all, both in Asgard and upon earth, shall descend the twilight, the evening, the everlasting night. This was called by the old German's "Götterdämmerung," "The twilight of the gods," and from it is taken the inspiration for one of Wagner's operas. Translated into the jargon of the physicist "Götterdämmerung" means "The entropy of the universe tends towards a maximum and its available energy towards a minimum."

So it is evident that the flow of energy from a high to a low level is a manifestation of a great universal

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[1]Scientific Monthly, July, 1924.

law. While what has been stated in the few preceding paragraphs is of only general interest here, it will be well to keep these facts in mind since in considering electrical phenomena we are always dealing with energy transformations.

Neutralization of Electric Charges Due to Flow of Energy from High to a Low Point

It will be recalled that in the illustration of imparting electrical charges by means of sealing wax and flannel, the opposite charges tended to neutralize each

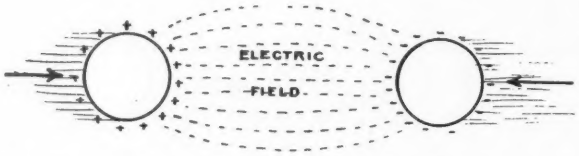


FIG. 2. TWO ELECTRICALLY CHARGED BODIES MOVING TOWARD EACH OTHER UNDER THE ATTRACTIVE INFLUENCE OF THE FIELD BETWEEN THEM

other. This is simply another illustration of energy seeking a lower level.

When the opposite charges were placed on the wax and flannel and the two substances separated, work was done in separating the bodies against the attractive influence due to the electric field. The two charged bodies, separated in this way possess potential energy in the same way that a body raised above the earth possesses potential energy by virtue of its elevation. In the case of the body above the earth, the measure of the potential energy is the product of the mass of the body by the distance through which it has been raised. In the case of electrical charges, the potential energy is

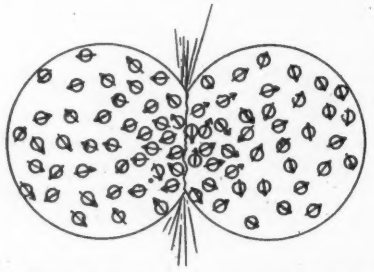


FIG. 3. AT THE INSTANT OF COLLISION OF THE TWO BODIES, THE KINETIC ENERGY WHICH THEY POSSESSED IS PASSED ON TO THE ATOMIC AND MOLECULAR SYSTEMS OF WHICH THEY ARE COMPOSED. THIS MANIFESTS ITSELF IN HAPHAZARD MOTION AMONG THE MOLECULES WHICH WE RECOGNIZE AS HEAT

measured in terms of the value of the charges producing the electric field and the distance between them. It may be thought of either as the amount of energy originally required to produce separation of the two bodies or the energy released when the two charges are neutralized, that is, when the excess of negative electrons on one body is returned to the positively charged atoms of the other body.

When two such oppositely charged bodies are permitted to move toward each other under the attractive force of the field between them, the potential energy of the bodies is gradually transformed into kinetic energy as the speed is accelerated.

At the moment they meet, or rather just before they meet, all the potential energy of the bodies has been transformed into kinetic energy and at the instant of impact this kinetic energy is delivered to the invisible molecules, atoms and electrons constituting the two bodies. This addition of energy imparts to the molecules and atoms of the bodies, haphazard motions which, as explained in Part V, we recognize as heat. As the charged bodies come together, the excess negative electrons on the negatively charged body unite with the excess protons on the positively charged body, forming normal atoms and thereby effecting complete neutralization.

The action just described and the energy relations involved in the separation and return of electrical charges lie at the base of all electrical phenomena with which we are familiar in everyday life. As pointed out previously, electrical phenomena manifest themselves only when unsatisfied atomic systems are brought into existence. Most of the atoms in the universe are satisfied and are therefore unaccompanied by electrical

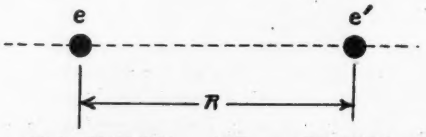


FIG. 4. TWO CHARGES e AND e' SITUATED AT A DISTANCE R FROM EACH OTHER WILL ACT UPON EACH OTHER ALONG THE LINE e-e' WITH A FORCE f ACCORDING TO THE FORMULA: $f = e\,e' \div R^2$

phenomena. Just as soon, however, as an electron is separated from an atom whose needs demand its presence, an electric field is set up between the unsatisfied systems which tends to bring them together.

Theory of Conduction Through Gases

In effecting neutralization of opposite charges of electricity in this manner, it is not necessary that the two bodies carrying the charges actually be brought together. The bodies carrying the charge may, and usually do, possess billions of normal atoms which play no part in the action. If the excess electrons on the negatively charged body could be removed and carried over to the positively charged body, or the excess protons could be removed from the positively charged body and carried to the negatively charged body, satisfaction would be just as complete.

The electric field existing between electrically charged bodies acts only upon the dissimilar charges by virtue of which it exists; it does not act upon the normal atoms or molecules of which the charged bodies may be composed and upon whose unsuspecting systems the divorced electrons have been lodged. Therefore if a means is provided to conduct the excess electrons back to their original family circle, the normal atoms need not be disturbed.

This process of carrying electric charges on one sign to those of the opposite sign to effect neutralization, regardless of the manner in which it is accomplished, is called conduction. It may or may not be done with the aid of normal atoms although the latter, when they are impressed into service, often facilitate the process

considerably. In a vacuum, the electrons or protons can pass bodily between the charged bodies along the lines of force constituting the electric field.

An electron, for instance, placed in an electric field in vacuum, will be urged in the direction of the positive charge producing the field. The force acting upon such an electron will depend upon the strength of the charge producing the field and the distance from this charge that the electron is placed. The force will vary with different positions of the electron with respect to the charge.

Potential Gradient and Coulomb's Law

In order to make this clear, we must consider what is known as the potential gradient. When two electric charges are concentrated at two points, isolated from all material supports and placed in empty space, the values of the charges being e and e′ respectively, and R, representing the distance between them as shown in Fig. 4, each charge will exert upon the other a force, f, along the line e e′. Numerically this force is given by the following equation:

$$f = e\,e' \div R^2$$

This law is known as Coulomb's law and, as may be noted, somewhat resembles the law expressing the force between two bodies due to the gravitational attraction between them. It is obvious from the equation, that if both charges are of the same polarity, that, is both positive or both negative, the value of the force will be positive, corresponding to a repelling force. If the charges are of opposite polarity, the force will be negative or attractive.

If one of the charges e or e′ in the above equation is a unit charge, that is having a value of one, it will be seen that the expression becomes $f = e \div R^2$. This equation, then, gives the force exerted by an electric field due to a charge e, upon a unit charge at any point in space. It expresses the peculiar state of the medium (in this case, the ether) due to the existence of the charge e, whereby the medium has the ability to exert a force on any charge which may be present by displacing the latter. This implies that the potential energy stored in a system of electric charges lies not in the bodies themselves, but in the medium that lies between them.

Variation of Force Due to Electric Charge

This was pointed out by Faraday almost a hundred years ago. It seems as though the medium surrounding an electric charge is stressed, so to speak, and a certain amount of potential energy is stored in it, which is capable of doing work whenever another charge is placed in the field and permitted to move under its action. The amount of energy available at any point is called the potential of that point and depends upon the value of the charge producing the field and the distance of the point in question from this charge.

In Fig. 5, with the aid of Coulomb's equation, we have shown how the value of the potential varies with distance from the charge. If we draw concentric circles around the charge, it is evident from the equation that the value of the potential is the same for any point on a particular circle; which of course applies equally well to the points on the surfaces of concentric spheres. Because of the inverse square variation of the force with distance, the potential increases rapidly as the charge producing the field is approached. Thus an electron, placed in the field close to the charge will be accelerated much more rapidly than it would if placed at some distance from the charge.

Now the curve representing the various values of potential at various distances from the charge is called the potential gradient curve. Its value at any point determines the speed at which an electron will fall, so to speak, towards the positive charge. As the electron

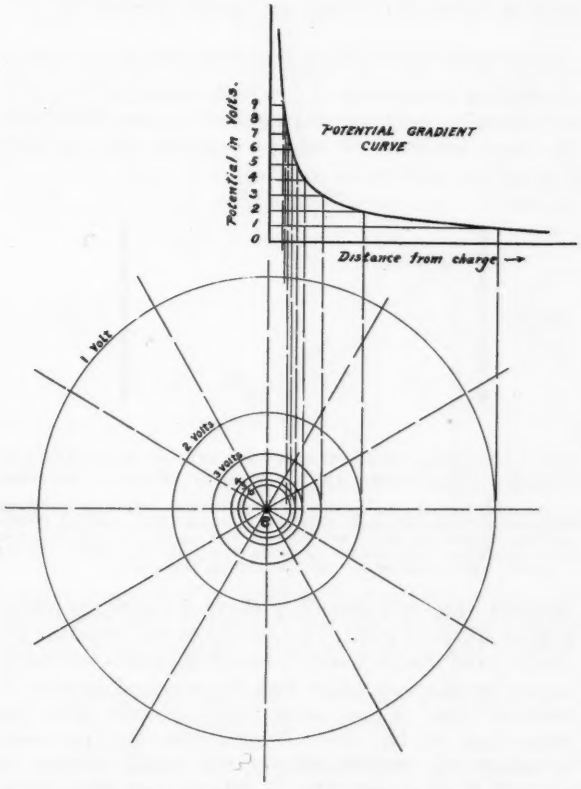


FIG. 5. THE VOLTAGE GRADIENT CURVE, AND METHOD OF PLOTTING IT

Below are shown a number of concentric circles which represent equipotential points around the charge, e. Due to the fact that the force due to the charge varies inversely as the square of the distance, the circles, it will be noted are not spaced equal distances apart.

approaches the positive charge, it acquires kinetic energy but its potential energy is decreased. At steep places in the potential gradient curve, the conversion of potential energy into kinetic energy is rapid, while at other places where the grade is easy, conversion is slow.

It must be understood that the total amount of potential energy available to a charge located at a particular point in the field is the same, regardless of the manner in which the charge is neutralized.

It does not matter in which manner or by what path the charge is conducted from a place of maximum potential energy to one of zero potential energy. Just as a weight lifted above the earth against gravity possesses a certain definite amount of potential energy due to its position regardless of how this potential energy

is recovered, so an electric charge in an electric field also possesses a definite amount of potential energy due to its position regardless of the method of recovery. The rate at which the potential energy of a charge is transformed into kinetic energy or the rate at which it is accelerated depends upon the potential gradient of the field, just as the rate at which the potential energy in a body elevated above the earth is converted into kinetic energy depends upon the steepness of the path down which it travels. Potential gradient is measured in terms of volts per inch or centimeter in the same way that the grade of a railroad or automobile road is measured in terms of feet rise per mile or per 100 ft.

Conduction Phenomena Between Charged Bodies

Having given some of the facts regarding the manner in which electrical charges can be neutralized and the forces involved, let us now consider what actually

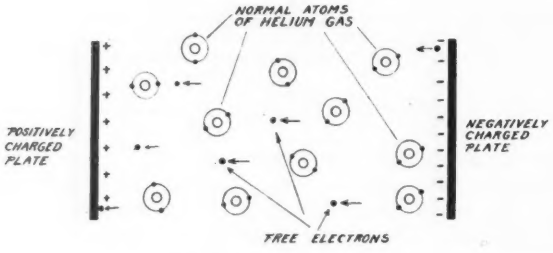


FIG. 6. CONDITIONS BETWEEN TWO OPPOSITELY CHARGED PLATES AN INSTANT AFTER THE CHARGE IS APPLIED

In addition to the normal helium atoms existing between the plates there are a few free electrons. The normal atoms are unaffected by the electric field due to the charge but the free electrons are drawn towards the positive plate. Their velocity will increase as they approach the plate.

happens when two oppositely charged plates are placed a short distance apart. According to our previous explanation of electric charges, one of the plates will carry a number of atoms which lack the required number of electrons, that is they have excess protons while the other plate will have more electrons than that necessary to satisfy the requirements of the atomic systems of which it is composed. Due to this unequal distribution of electrons and protons among the atoms of both plates an electric field will exist between the plates.

Under these conditions, neutralization of the charges may be brought about in three ways: First, the excess electrons on the negative plate may travel across the space to the positive plate; second, the excess protons on the positive plate may be transferred to the negative plate and, third, some of the molecules of gas between the two plates may be impressed into service to effect the interchange of protons. In a perfect vacuum of course, only the first two methods would be possible. The third method is the most usual and also the most interesting.

Normal atoms and molecules as has been pointed out play no part in electrical phenomena and if only normal atoms or molecules of gas exist between the charged plates, nothing happens. If in addition to the normal atoms, however, there are a number of free electrons, that is, electrons which are not attached to any atoms and which lead a more or less bachelor existence, things become interesting. These electrons, being free to move, are acted upon by the electric field and are drawn to the positive plate at a speed which depends upon the potential gradient of the field.

As the free electrons are accelerated toward the positive plate occasionally, one of these normal gas atoms may lie in its path, and if the speed of the electron is high enough the force of the collision may be sufficient to knock one of the external electrons out of the normal atom. Now, if you recall, in part two of this series, we showed that when a neutral atom loses an external electron, the atom is said to be ionized, and is positively charged.

So if such a collision of a free electron and a normal atom occurs, and it happens quite often, in addition to the free electron which did the damage, we now have a positively charged atom and another free electron. Under the influence of the electric field, the two electrons are drawn to the positive plate and the positively charged atom is drawn to the negative plate. The latter, however, moves much more slowly than the former due to its much greater size.

Under the continued action of the electric field, the two free electrons (together with many others which have gone through a similar procedure) are accelerated towards the positive plate and again collide with normal atoms, knocking more electrons off. As might be expected, the process is cumulative, resulting in an ever increasing number of free electrons, and positively charged atoms. The electrons finally reach the positive plate where they combine with the unsatisfied atomic

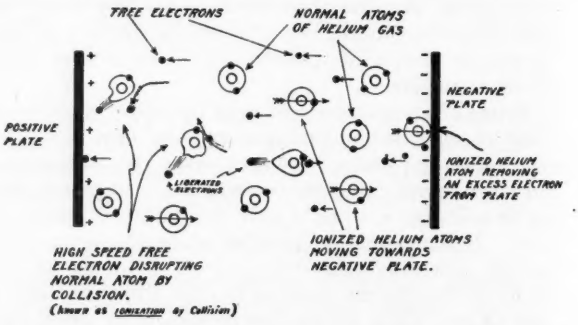

FREE ELECTRONS
NORMAL ATOMS OF HELIUM GAS
NEGATIVE PLATE
POSITIVE PLATE
IONIZED HELIUM ATOM REMOVING AN EXCESS ELECTRON FROM PLATE
LIBERATED ELECTRONS
IONIZED HELIUM ATOMS MOVING TOWARDS NEGATIVE PLATE.
HIGH SPEED FREE ELECTRON DISRUPTING NORMAL ATOM BY COLLISION.
(known as IONIZATION by Collision)

FIG. 7. CONDITIONS BETWEEN THE CHARGED PLATES SHOWN IN FIG. 6 AFTER THE CHARGE HAS BEEN ON A SHORT TIME

Due to the accelerating action of the field upon the free electrons, a number of the latter have collided with normal gas atoms in their path and have knocked external electrons out of the orbits of the neutral atoms. This imparts a positive charge to the atom and it at once moves towards the negative plate under the action of the electric field. Normal atoms which have not been disrupted in this manner are unaffected. This process of knocking electrons off normal atoms is called ionization. The liberated electrons together with the free electrons responsible for their freedom move toward the positive plate where they neutralize the positive charge.

systems, thus neutralizing the charge. The positively charged gas atoms pass to the negative plate where they acquire from the plate an excess electron, thus reducing the negative charge from the plate and becoming normal atoms of gas again.

In this manner, it will be seen that the existence of a few free electrons between the charged plates can, by disturbing the satisfaction of normal atoms between the plates, impress the latter into service for bringing about neutralization of the charge on the plates. This is called gaseous conduction and explains why electricity can flow across a gas space between oppositely charged poles or electrodes.

In the above explanation, we have assumed the existence of a number of free electrons in the space between the charged plates. This might seem an unjustified assumption but actually it is not. In the gases of the atmosphere, there are nearly always some free electrons present. How these free electrons originate is a vast subject in itself and will be dealt with in later articles. They are being produced constantly and normally combine with positively charged gas atoms at the same rate that they are produced.

Other interesting things happen in the space between the charged plates which have a bearing upon the conducting properties of a gas and these will be taken up in the succeeding article.

Reactive Component in A.C. Circuits

PART VII. DETERMINATION OF REQUIRED CORRECTIVE CAPACITY BY MEANS OF TRIGONOMETRICAL TABLES. BY V. E. JOHNSON

IN MAKING POWER factor surveys involving a large number of groups, feeders, or motors, much time and labor can be saved by making use of various curves and tables that have been prepared for that purpose. The majority of these are based on trigonometric functions and are so arranged as to provide a quick and accurate solution to almost any problem. A multiplicity of them is available; those given here have been chosen because they appeared to be the most simple and because they fit conditions that are commonly met with.

THE LOAD TRIANGLE

Inasmuch as the energy output, reactive component, and total kilovolt-amperes are related to each other as are the two sides and hypotenuse of a right triangle, these relations can be expressed as trigonometric functions. This requires only an elementary knowledge of this branch of mathematics; in fact, it is possible to solve the problems commonly met with no understanding of it at all.

The sketch shows a common method of constructing this triangle; the sides and hypotenuse are marked to indicate the quantities they represent. The angle AOB included between the sides OA and OB is the angle of lag and its magnitude measured in degrees represents the time displacement between the current and voltage. When OA and OB coincide, the angle AOB becomes zero, OA becomes equal to OB and the reactive component AB disappears. When OA and OB are at right angles, OA becomes equal to AB and coincides with it and the power component OB disappears.

Electrically, the ratio of OB to OA is known as the "Power Factor"; trigonometrically, it is known as the cosine of the angle AOB, hence the rule that the power factor is equal to the cosine of the angle of displacement. The three sides of the triangle are also related in the manner expressed by the ordinary arithmetical formula

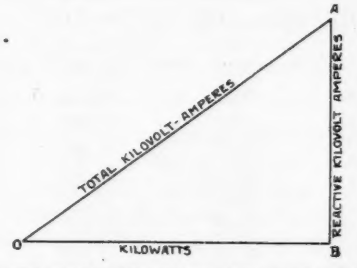
$$OA^2 = OB^2 + AB^2 \text{ from which may be derived}$$
$$OA = \sqrt{OB^2 + AB^2}$$
$$OB = \sqrt{OA^2 - AB^2}$$
$$AB = \sqrt{OA^2 - OB^2}$$

These three expressions combined with those defining power factor

(1) $P.F. = OB \div OA$
(2) $OB = OA \times P.F.$
(3) $OA = OB \div P.F.$

make it possible to resolve any load into its components, or to combine any components into the total kilovolt-amperes and to derive the power factor. This process has been completely illustrated by numerous examples given in the preceding article.[1]

This method of calculation is accurate and is practically entirely an arithmetical procedure. It has the disadvantage that it involves finding the square and the square root of numbers that are sometimes cumbersomely large, therefore requiring a great deal of labor.



THE LOAD TRIANGLE SHOWING THE RELATION OF THE KV.A., KW. AND R. KV.A.

TRIGONOMETRIC RELATIONS BETWEEN THE SIDES OF THE LOAD TRIANGLE

Just as Kw. ÷ Kv.a. is the fraction that is numerically equal to the cosine of the angle AOB, so there are trigonometric expressions for the relations between any other pair of triangle sides. This simplifies the calculations a great deal, in that it eliminates much tedious arithmetical computation and permits the derivation of any unknown component by a simple process of multiplication or division. The relation between the reactive kv.a. and the total kv.a. is expressed by the following formulas:

$$(4) \qquad \frac{\text{R. kv.a.}}{\text{Total kv.a.}} = \frac{AB}{AO} = \text{sine angle AOB}$$

From this follows

$$(5) \qquad \text{R. kv.a.} = \text{total kv.a.} \times \text{sine angle AOB}$$

$$(6) \qquad \text{Total kv.a.} = \frac{\text{R. kv.a.}}{\text{sine AOB}}$$

In a similar manner, the relation between the reactive and power components is expressed by the formulas:

[1] Part VI, page 724, July 1 issue.

$$(7)\quad \frac{\text{Reactive kv.a.}}{\text{kw.}} = \text{tangent angle AOB}$$

From this follows

$$(8)\quad \text{Reactive kv.a.} = \text{kw.} \times \text{tangent AOB}$$

$$(9)\quad \text{kw.} = \frac{\text{R. kv.a.}}{\text{tangent AOB}}$$

Although the formulas (1) to (9) use trigonometric terms, these are essentially nothing but convenient expressions for describing the various ratios involved. They require no other knowledge of this branch of mathematics and should be treated as straight arithmetical solutions. Any table of "natural functions" gives the sine, cosine and tangent of any angle in parallel columns, so that given one, the others are immediately known.

CONDENSED TABLE OF TRIGONOMETRIC RELATIONS[2]

Angle of lag AOB approx.	Power Factor Cos AOB kw./kv.a.	Reactive Factor Sine AOB R. kv.a./kv.a.	Tan. AOB R. kv.a./kw.
0°	1.00	0.000	0.000
8° 06′	0.99	0.141	0.142
11° 30′	0.98	0.199	0.203
14° 10′	0.97	0.243	0.250
16° 20′	0.96	0.280	0.291
18° 20′	0.95	0.312	0.328
20°	0.94	0.341	0.363
21° 40′	0.93	0.367	0.395
23°	0.92	0.392	0.426
24° 30′	0.91	0.414	0.456
25° 50′	0.90	0.436	0.484
28° 20′	0.88	0.475	0.540
30° 40′	0.86	0.510	0.593
32° 50′	0.84	0.543	0.646
34° 50′	0.82	0.572	0.698
37°	0.80	0.600	0.750
41° 30′	0.75	0.661	0.882
45° 30′	0.70	0.714	1.020
49° 30′	0.65	0.760	1.169
53°	0.60	0.800	1.333
56° 30′	0.55	0.835	1.517
60°	0.50	0.866	1.732
66° 30′	0.40	0.916	2.290
72° 30′	0.30	0.953	3.171
78° 30′	0.20	0.980	4.900
84° 10′	0.10	0.994	9.923
90°	0.00	1.000	Infinity

APPLICATION OF THE TRIGONOMETRIC TABLE

Example 1. Assume a load of 1000 kv.a. Find the reactive and power components with a power factor of 88 per cent. Substituting values from the table, in Formula (2)

$$\text{Kw.} = 1000 \times 0.88 = 880$$

Substituting values from the table, in Formula (5)

$$\text{R. kv.a.} = 1000 \text{ kv.a.} \times 0.475 = 475$$

Example 2. Assume a load of 1000 kw. at 75 per cent power factor. Find the reactive and the total kilovolt-amperes.

[2]Tables accurate to more decimal places are available in any text-book on trigonometry and in many hand books.

Substituting values from the table, in Formula (3)

$$\text{Total kv.a.} = 1000 \div 0.75 = 1333$$

Substituting values from the table, in Formula (8)

$$\text{R. kv.a.} = 1000 \times 0.882 = 882$$

Example 3. Assume a load having a reactive component of 500 kv.a. and a power component of 900 kw. Find the power factor and the total kilovolt-amperes.

Substituting in Formula (7)

$$500 \div 900 = 0.555 = \text{tangent of AOB}$$

There is no value in the table that exactly corresponds to this, the nearest being 0.540. The calculated value 0.555 is 15/53 of the "numerical distance" from 0.540 and the next value 0.593 in the table. The power factor will therefore be 15/53 of the "distance" between the value 0.88 and the value 0.86 in the power factor column. This "distance" is 0.02, so that the actual power factor corresponding to a tangent of 0.555 will be

$$0.88 - \left(0.02 \times \frac{15}{53}\right) \text{ or } 0.874$$

This process of arriving at intermediate values is called interpolation.

From Formula (3) total kv.a. = $900 \div 0.874 =$ 1030 kv.a. approximately.

Example 4. Assume a load having a total kv.a. of 1000 and a power component of 600 kw. To find the reactive component.

Solution A:

Substituting in Formula (1)

$$\text{P. f.} = 600 \div 1000 = 0.60$$

Referring to the condensed table, a power factor of 0.60 is found to correspond to a sine of 0.800.

Substituting in Formula (5)

$$\text{R. kv.a.} = 1000 \times 0.800 = 800$$

Solution B:

Referring to the condensed table, a power factor of 0.60 is found to correspond to a tangent of 1.333.

Substituting in Formula (8)

$$\text{R. kv.a.} = 600 \times 1.333 = 800$$

CALCULATION OF CORRECTIVE KILOVOLT-AMPERES REQUIRED

Tables of trigonometric functions, such as the condensed one given above, provide a ready means for finding the corrective kv.a. required to cancel out any predetermined portion of the wattless component of any load. The underlying principle is the same as that used in the previous arithmetical computations, while the actual process can best be shown by actual examples. In order to permit of a direct comparison of the two methods, the values and classification previously used will be repeated.

Class I. With the present and the desired future characteristics known, determine the amount of corrective kilovolt-amperes required.

Example 1. Assume a load of 600 kv.a. at 60 per cent power factor lagging. Determine the corrective kv.a. required to raise the power factor to unity, keeping the power output constant.

Solution:

The condensed table indicates that a cosine of 0.60 corresponds to a sine of 0.80.

Substituting in Formula (5)

600 kv.a. × 0.80 = 480 reactive kv.a.

To cancel this component and raise the power factor to unity will require the addition of 480 kv.a. at zero power factor leading.

Example 2. To determine the corrective kilovolt-amperes required to raise the power factor of the foregoing load to 90 per cent power factor.

Solution:

Tabulate the components under each condition as follows:

600 kv.a. at 60 per cent p. f. = 600 × 0.60
= 360 kw. (using Formula (2))

600 kv.a. at 60 per cent p. f. = 600 × 0.80
= 480 R. kv.a. (using Formula (5))

The reactive component at 90 per cent p. f. is

360 kw. × 0.484 = 174 R. kv.a.

(From table and Formula (8))

The corrective capacity will therefore be (with fixed power output)

480 — 174 = 306 kv.a. at zero p. f. leading.

Example 3. Assume a load of 600 kv.a. at 60 per cent power factor to which is to be added 500 kv.a. at 80 per cent power factor and 300 kv.a. at unity. To determine the resultant power factor and the corrective kilovolt-amperes required to raise it to 100 per cent.

Solution:

Resolve the present and future loads into their power and reactive components and tabulate as follows:

Formula (2)	Kw.	Formula (8)	Reactive kv.a.
600 kv.a. = 600 × 0.60 =	360	and 600 × 0.80 =	480
500 kv.a. = 500 × 0.80 =	400	and 500 × 0.60 =	300
300 kv.a. = 300 × 1.00 =	300	and 300 × 0 =	000
Total load	1060		780

Substituting these values in Formula (7)

Tangent AOB = 780 ÷ 1060 = 0.73

Referring to the table and interpolating between the given values, it is found that a tangent of 0.73 corresponds to a cosine of 0.805, which therefore is the power factor of the total load. This can be raised to unity by adding 780 reactive kv.a. at zero power factor leading.

Class II. Knowing the present load and the characteristics of a corrective piece of apparatus to be added, to determine the resultant power factor.

Example 1. Assume a load of 600 kv.a. at 60 per cent power factor, lagging, to determine the improvement which will result from adding 200 kv.a. at 90 per cent power factor lagging.

Solution:

Resolve the present and the added load into their power and wattless components, tabulating the results as follows:

By Formula (2)	Kw.	Formula (5)	Reac. kv.a.
600 kv.a. = 600 × 0.60 =	360	and 600 × 0.80 =	480
200 kv.a. = 200 × 0.90 =	180	and 200 × 0.436 =	87
Total load	540		567

Substituting these values in Formula (7)

Tangent AOB = 567 ÷ 540 = 1.05

Referring to the table and interpolating between the given values, a tangent of 1.05 is found to correspond to a power factor of 69 per cent.

CORRECTION BY MEANS OF LOADED SYNCHRONOUS MOTORS

Example 1. Assume a present load of 600 kv.a. at 60 per cent power factor. Determine the corrective effect of a 200-kv.a. synchronous motor, carrying 100-kw. load (including losses) and operating at a leading power factor.

Solution:

Resolve the present and the added load into their power and reactive components and tabulate the results as follows:

(Formulas (2) and (8))

600 kv.a. at 60% p. f. = 360 kw. and 480 reactive kv.a.

(Formulas (1) and (8))

200 kv.a. at 50% p. f. = 100 kw. and 173 reactive kv.a.

Total load 460 kw. and 307 reactive kv.a.

Substituting these values in Formula (7)

Tangent AOB = 307 ÷ 460 = 0.667

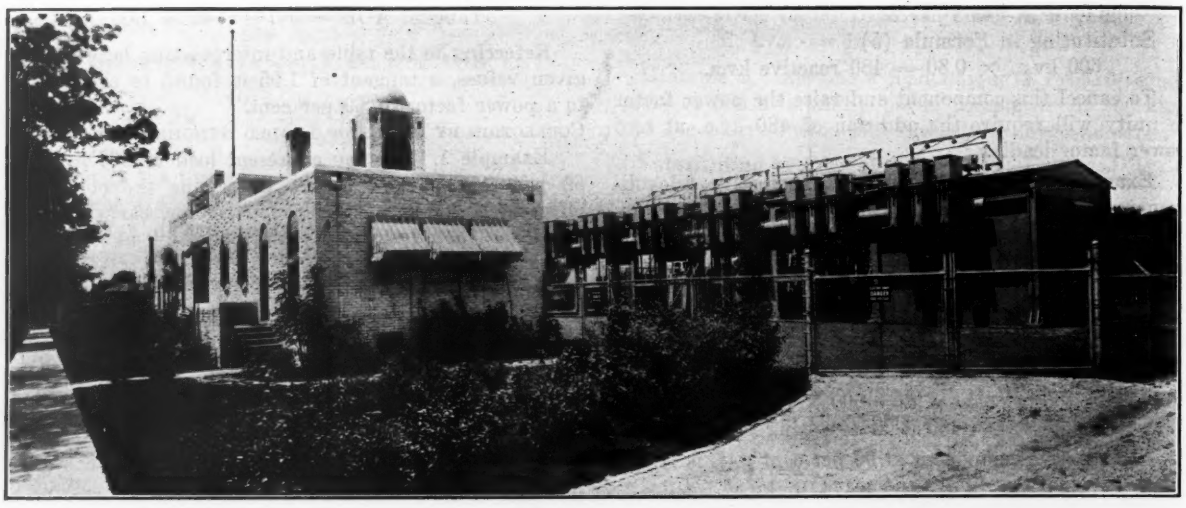
Referring to the table and interpolating between the given values, it is found that a tangent of 0.667 corresponds to a power factor of 83 per cent.

It will be seen from the foregoing typical examples that much labor is avoided by using the trigonometrical tables. These form a part of almost any mathematical text book, so that data are ordinarily at all times available for the solution of any power factor problems.

AVERAGE DAILY PRODUCTION of electricity by public-utility power plants in May was 229,700,000 kw-hr., about one-half of 1 per cent larger than the average daily output in April, according to a statement issued by the Department of the Interior. The output for May was 8 per cent larger than that for May, 1927, but the output for March and April was only 6 per cent larger than for the same months of 1927. Production of electricity by the use of water power in May surpassed the records that were established in April. More electricity was produced by the use of water power in May than in any previous month, the total being 3,179,000,000 kw-hr. The average daily rate of production of electricity by water power was the largest on record and for the first time exceeded the 100,000,000 mark, with an average daily output of 102,500,000 kw-hr. The proportion of the total output produced by water power was 44.6 per cent, which surpasses all previous figures.

UNITED STATES CIVIL SERVICE COMMISSION announces open competitive examinations for associate and assistant engineers in architectural, mechanical, electrical and structural branches. Applications for the positions must be on file with the Commission at Washington, D. C., not later than August 15. The examinations are to fill vacancies in the Office of the Supervising Architect, Treasury Department, for duty in Washington, D. C., or in the field.

Full information may be obtained from the Commission at Washington, D. C., or from the post office or customhouse in any city.



33-Kv. Metal Clad Outdoor Switching Station

NEW OUTDOOR STATION OF PUBLIC SERVICE CO. OF NORTHERN ILL. IS DISTINCT DEPARTURE FROM CONVENTIONAL DESIGN

AN INTERESTING installation of switching equipment has recently been completed and placed in service at Wheaton, Ill., by the Public Service Company of Northern Illinois. This is a 33-kv. outdoor switching equipment which is a distinct departure from conventional designs. It handles the six circuits shown on wiring diagram shown in Fig. 1. The distinguishing characteristic of this switching station is that all the 33-kv. buses and connections are housed in grounded metal pipes in such a way that it is impossible to make casual contact with the high voltage conductors. Each of the three phases has its own independent set of pipe enclosures so that there are two walls of grounded metal separating the conductors of one phase from the conductors of each of the other two phases. The different pipe sections are joined together by suitably designed junction boxes. Figure 2 shows this substation in cross section.

All 33-kv. conductors are of copper tubing, factory insulated for full working potential. They are centered in the pipes by insulating spools suitably spaced to give the required support. The space between the conductors and pipes and the space in the junction boxes is filled with insulating oil, the oil system terminating in conservators similar to those used on transformers. Diaphragms are provided in the longitudinal bus enclosures between adjacent circuits so that for each circuit there are six longitudinal oil compartments (one for each of the six buses) and three cross compartments, giving a total of nine compartments per circuit. These nine compartments are connected through manifolds to three oil conservators, corresponding to the three phases.

Disconnecting switches have been eliminated. The oil circuit breakers are disconnected from their circuits by lowering them bodily with a traveling motor-operated elevator. The circuit breaker may be dropped to supports at the "disconnected" position where its mechanism may be tested or its tanks may be lowered to permit inspection of the contacts. Or, it may be lowered to the "transport" position and rolled into a repair

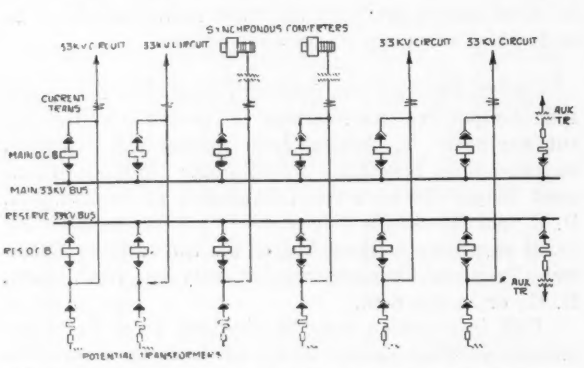


FIG. 1. SINGLE LINE DIAGRAM OF 33,000-V. CONNECTIONS

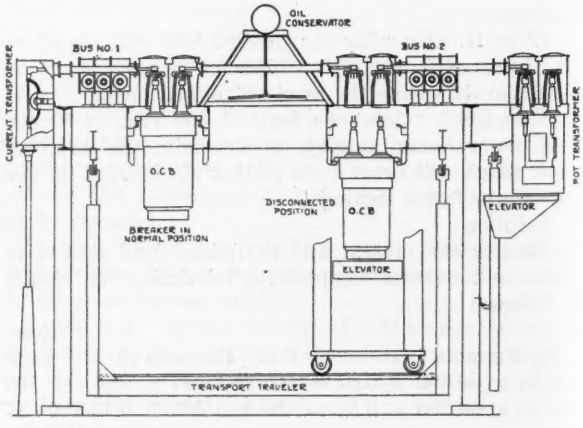


FIG. 2. TYPICAL CROSS SECTION OF WHEATON OUTDOOR METAL-CLAD SWITCHING GEAR

Details of Outdoor Switching Equipment at Wheaton

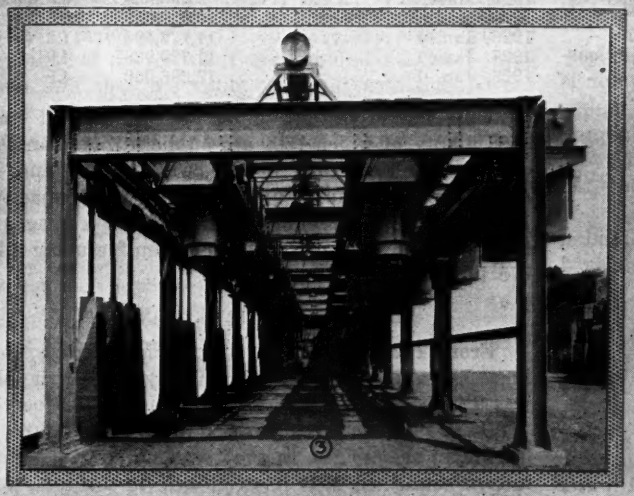
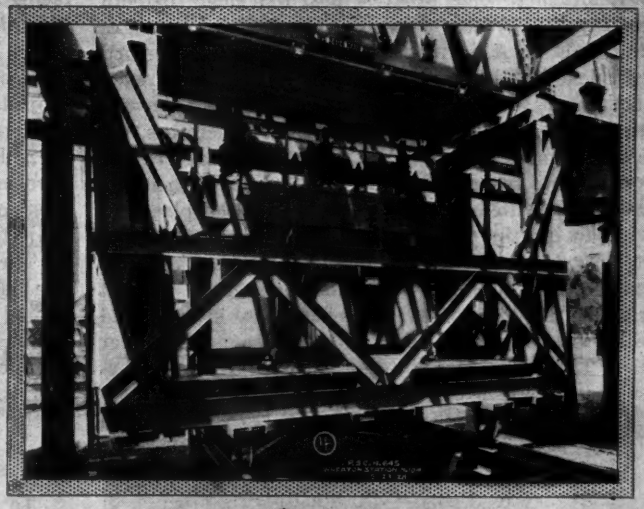


Fig. 3. End view of switch gear. At the left may be seen the 33-kv. cables of the circuits entering the switch gear. At the top is a conservator and at the rear center may be seen the carriage by means of which the circuit breakers are lowered for inspection. At the right may be seen one of the four three-phase transformers with the 33-kv. cable connections from the switch gear.

Fig. 4. The truck which travels on the transverse rails of the carriage. A circuit breaker is on the elevator in position to be raised to its housing. Any circuit breaker may be dropped to supports at the "disconnected" position where its mechanism may be tested or its trucks may be lowered to permit inspection of the contacts. If desired it may be lowered to the transport position and rolled into a repair house while another unit is substituted.



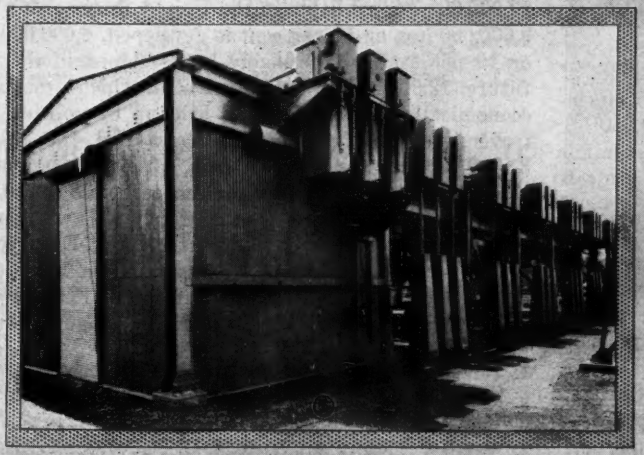


Fig. 5. Rear view of switch gear. The auxiliary transformers on reserve bus may be seen in foreground on side of enclosed inspection bay. 33-kv. cables entering switch gear with current transformer boxes above may be seen on the side of the structure. When circuit breakers are to be overhauled they are rolled into the inspection bay where work may be done regardless of the weather.

house at the end of the structure. If desired, another breaker may be substituted for the one removed. As the circuit breaker bushings leave the enclosing shells which support the stationary contacts, the openings are automatically closed by shutters which effectually seal off the live contacts. The method of handling the circuit breakers is shown in Fig. 2.

Three simple rugged interlocks prevent (1) releasing the breaker clamping device unless the elevator is in its proper position; (2) dropping a breaker unless the breaker is open, and (3) operation of the clamping device with the breaker disconnected. Interference members also prevent unbolting of the tanks unless the breaker is in the disconnect position.

This equipment was designed to give a maximum degree of protection to operators and to men engaged in maintenance work on high voltage stations.

Water Power Development in 1927 in United States

NO OUTSTANDING development has occurred in 1927 in either the theory or utilization of water power, although some progress has been made in both lines, says the Water Power Development Committee of the N. E. L. A. in its June, 1928 Convention report.

Efficiency of hydraulic turbines has been improved to the point where it seems there is little room for betterment. As in the design of electric generators, the efficiency is now so high that a nearer approach to 100 per cent can scarcely be expected. Improvement in details has resulted in reaction turbines being placed in service during the year showing an efficiency of 94 per cent over a considerable range. Perhaps the most promising field for water-wheel improvement at present lies along the lines of greater efficiencies in low head wheels with higher speeds and corresponding lower costs. There is much interest among hydraulic engineers at present over tests on the experimental Stevenson Creek Dam in California, also in the use of small scale models in hydraulic studies.

Report of Federal Power Commission

During the year the Federal Power Commission issued nine preliminary permits involving 419,407 hp. primary capacity and an estimated installed capacity of 772,800 hp. Eighteen major licenses were issued involving 85,571 hp. of primary capacity and 574,880 hp. of ultimate installed capacity. Twenty-two minor licenses or licenses for minor parts of complete projects were issued involving 43,553 hp. primary capacity and 80,928 hp. of ultimate installed capacity.

Eleven projects were completed or put in operation during the year with an aggregate installed capacity of 217,694 hp. Thirty-one new projects having an installed capacity, when completed, of 362,000 hp., have been started during the fiscal year ending June 30, 1927, bringing the total of projects completed or under construction at the close of the year to 128 with a proposed ultimate installation of 4,610,000 hp.

The United States Geological Survey reports that on January 1, 1928, the developed water power in the United States in plants of 100 hp. or more was 12,296,000 hp., showing an increase of 575,000 hp. or 4.9 per cent during 1927. The figures for recent years are as follows:

Date	Horsepower	Increase %
1921, November	7,926,958	
1924, March	9,086,958	14.6 (2.3 yr.)
1925, March	10,037,655	10.5
1926, Jan. 1	11,176,596	11.3 (.8 yr.)
1927, Jan. 1	11,720,938	4.9
1928, Jan. 1	12,296,000	4.9

This 12,296,000 hp. developed is divided among 3397 plants, of which 1600 are public utility plants with capacity of 10,538,381 hp. (7,861,632 kw.) and 1797 miscellaneous manufacturing plants with capacity of 1,757,619 hp. The public utility plants average 6587 hp. each and the miscellaneous manufacturing plants 978 hp. each.

Development Is Slowing Up

From 1922 to 1925 inclusive, the average annual increase in installed capacity in hydro-electric plants was 9 per cent. In 1926 and 1927, it was 4.9 per cent. While the period is too short to make these figures conclusive in themselves, they correspond so well with the known conditions that it seems safe to say that we are facing a slowing up in hydro-electric development. Two factors are principally responsible:

1. Remarkable reductions in steam power costs in the past five years have made many water power projects economically unattractive today that looked attractive 5 yr. ago.

2. Political controversies and restrictive state laws have made it impossible for the time being to develop most of the larger and more feasible water power projects.

The United States Geological Survey estimates the total developed and undeveloped water powers of the United States available 50 per cent of the time at 59,000,000 hp., corresponding to about 80,000,000 hp. installed capacity. The 12,296,000 hp. installed corresponds, therefore, to 9,600,000 hp. available 50 per cent of the time and leaves 49,400,000 hp. still undeveloped.

Analysis of Power Developed and Available

To sum up, an analysis of the inventory of the 59,000,000 hp. available in the United States shows that 9,600,000 hp., or 16 per cent is developed, 6,000,000 hp., or 10 per cent will probably be developed in the near future, 12,000,000 hp. or 20 per cent, which probably is economically feasible, is being held up by political controversies or restrictive state laws and the balance 31,400,000 hp., or 54 per cent, probably cannot be profitably developed under present economic conditions.

Results of this analysis check fairly well with figures given by Major Glen E. Edgerton, Chief Engineer of the Federal Water Power Commission, in an address before the Mid-West Power Conference, February 15, 1928. A summary of Major Edgerton's figures is:

	Horsepower
1. Total water power in U. S. (50 per cent of time)	55,000,000
2. Corresponding installed capacity	75,000,000
3. Probably 75% of this is under federal jurisdiction.	
4. Installed capacity Jan. 1, 1928, about	12,000,000
5. Licensed by Federal Water Power Commission, but not constructed	4,000,000
6. Under preliminary permit from F. W. P. C.	5,500,000
7. Applications not acted upon	15,000,000

Casualties in preliminary permits up to date have been so heavy that it would be conservative to assume that not more than 75 per cent of item 6, or 4,125,000 hp., will be found feasible.

If it be assumed that the undeveloped water powers not under federal jurisdiction have the same relative probability of development as those under federal jurisdiction and that the ratio of power available 50 per cent of the time to installed capacity is 55 to 75, the following may be deduced from Major Edgerton's figures:

	Horsepower	Per cent
1. Total water power in U. S. available 50% of time	55,000,000	100
2. Total developed water power, January, 1928	8,800,000	16
3. Development probable in next 10 to 15 years	5,900,000	10.7
4. Development probably feasible if political controversies be adjusted	11,000,000	20
5. Probably not now economically feasible	29,300,000	53.3

Output of Hydro Plants in Kilowatt-Hours

Following is a statement of electric energy developed in the United States by hydraulic plants, 1921 to 1927:

Year	Kw-hr.	% Increase
1920	16,150,000,000	...
1921	14,970,000,000	7.3
1922	17,207,000,000	15.0
1923	19,343,000,000	12.4
1924	19,969,000,000	3.2
1925	22,356,000,000	12.0
1926	26,189,000,000	17.1
1927	29,875,000,000	14.0

It will be noted that the increase in kilowatt-hour output does not correspond directly with the increase in installed capacities heretofore given. This is due principally to the variation in rainfall from year to year.

Average kilowatt capacity during 1927 of the hydro plants reporting to the Geological Survey was approximately 6,970,000. The average kilowatt capacity during the same period for the fuel burning plants reporting was about 19,580,000. The following table shows the average capacity factor at which the hydro and steam stations operated in 1927:

	Capacity kw.	Output, 1927, kw-hr.	Equiv. Continuous kw.	Capacity Factor
Hydro stations	6,970,000	28,875,000,000	3,410,388	48.9
Steam stations	19,580,000	50,330,000,000	5,745,434	29.3

Unique Generators for Ford Co.

By T. Harvey*

LAST YEAR, the Ford Motor Co. installed two 1250-kv.a., 0.8 p.f., 1000-kw., 4600-v., 3-phase, 60-cycle, engine-driven generators of unique design. One of them is now in operation at the Ford Motor Co. plant at Chester, Pa., and the other at the plant of the Lincoln Motor Co., a division of the Ford Motor Co. at Detroit.

As will be noted from the illustrations, the machines are direct-connected to vertical engines of the marine type. These engines were removed from ships which Mr. Ford purchased from the U. S. government and scrapped. They were re-designed, and are now in successful operation. The photographs from which the illustrations were made were taken in the Chester plant.

Because of lack of space, especially lengthwise of the machines, the Ford engineers wanted the generators built with but one bearing.

A tentative set of specifications, with working drawings, was prepared, and it was found that the design

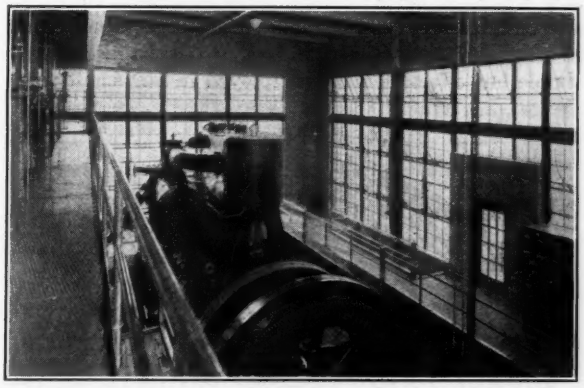


FIG. 1. MARINE ENGINE DRIVING SPECIAL DESIGN GENERATORS AT FORD CO. PLANT

requested by the Ford Company would be entirely feasible. The two machines were built and installed and a third, now being built, is to be shipped to Brazil for the Ford rubber development at Sao Paulo. The single bearing between the flywheel and the generator may be seen in Fig. 1. This bearing was designed on the presumption that the weight of the flywheel would be balanced by the weight of the rotor, and very careful calculations had to be made to obtain the proper flywheel effect and at the same time, to balance the weights

FIG. 2. ANOTHER VIEW OF THE MACHINE SHOWING THE OVERHANGING DESIGN OF THE GENERATOR

in such a way that no extra strain, because of the flywheel, would be placed on the bearing of the engine. By utilizing this plan, considerable space has been saved and the cost decreased.

Figure 2 indicates clearly the overhanging design of the generator, showing the shaft end together with the generator spider.

*General Electric Company, Detroit, Mich.

Small Plant Keeps Records in Simple Manner

SUFFICIENTLY ACCURATE DATA ARE OBTAINED WITH COMPARATIVELY FEW INSTRUMENTS AND DATA SHEETS. BY J. O. BENEFIEL

RECORDS AND COSTS are important to small as well as to large plants but the expense of installing a system of the type suitable for a large power plant is often prohibitive in a small one. Description of the simple but effective means employed in our small plant

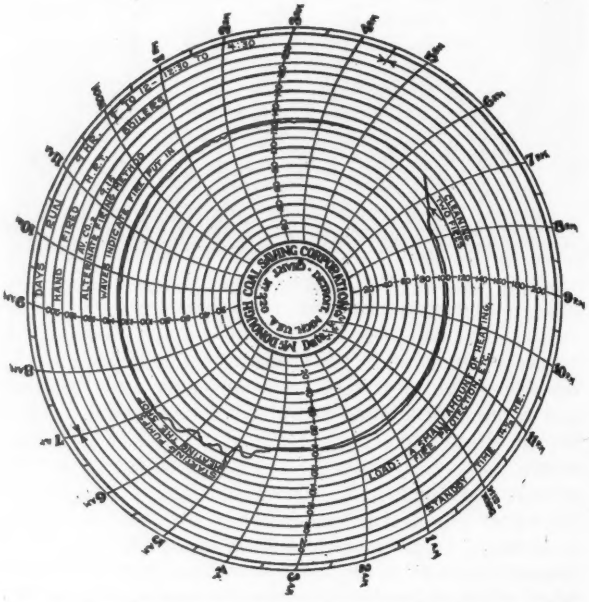


FIG. 1. STEAM PRESSURE CHART SHOWS VARIATION OF DAY AND NIGHT LOAD

may, therefore, be appreciated by the small plant operator.

Power cost is an insignificant part of the entire operating expense of our plant, which is for the manufacture of tools. Our power equipment consists of four 200-hp. H.r.t., hand-fired boilers; one simple noncondensing Corliss engine; an air compressor and a number of steam pumps. Except for heating the feedwater, the exhaust is wasted during warm weather; during the heating season, there is just about enough exhaust steam for plant heating. At least half of the high-pressure steam is used for process work and for pumping air, water and brine. In addition to this, between 25,000 and 35,000 kw. of electric power is bought each month. The boiler water is metered through a turbine hot water meter, which is calibrated by means of a tank holding a known quantity of water.

EVAPORATIVE TESTS CHECK ROUTINE RECORDS

Occasionally evaporative tests are run in which coal and ash are weighed and water consumption is taken from the meter readings. The weight of ash includes coal lost through the grates, since such lost coal makes no steam for us. Our only method of getting the stack temperature is to insert a high-temperature thermometer in an oil well in the breeching. In making up our daily log, we divide the number of pounds of water fed to the boilers by 7½; this gives us amounts representative of the weight of coal burned. With the coal we are now using, our last test showed an average evaporation of 8.16 lb. of water per lb. of coal, which is about 8 per cent greater than the factor 7½ that we have chosen, the reduction being made to take care of incidental losses and considered sufficiently accurate.

METHODS OF SECURING DATA

Temperature of the feedwater, as indicated by a thermometer in the feed line, is about 206 to 208 deg. F. CO_2 is indicated by an Orsat reading of an 8-hr. sample. The economical rating of the boiler is 600 to 700 hp. We get better results running four boilers on a 600-hp. load than we do running three on the same load, due probably to lack of combustion space, the distance be-

TABLE I. DAILY RECORD OF PERFORMANCE AND COSTS

		Daily Record February 1928										
		Wed 1	Thur 2	Fri 3	Sat 4	Sun 5	Mon 6	Tues 7	Wed 8	Thur 9	Fri 10	Sat 11	Sun 12
Evaporation day, lbs.		153,600	172,800	171,800	43,520	37,520	171,800	182,400	170,400	171,400	178,600		
Coal day	Tons	12.2	11.5	11.9	3.7	2.3	11.9	10.15	11.35	11.95	12.25		
	Cost in dollars	42.45	44.55	41.25	14.30	8.92	41.25	42.00	44.03	41.50	47.52		
Evaporation nights, lbs.		17,040	45,750	52,440	26,230	45,140	48,800	57,170	51,200	43,150	43,780		
Coal nights	Tons	6.9	3.3	2.75	2.2	3.75	4	4.9	4.25	4	3.35		
	Cost in dollars	24.20	14.75	10.67	8.53	14.56	14.50	18.96	16.45	14.50	14.00		
Boiler room help day	Hrs.	33½	33½	33½	13	5	33½	33½	33½	33½	33½		
	Cost in dollars	15.83	15.44	15.44	6.05	2.75	15.44	15.44	15.44	15.44	15.44		
Day watch	Hrs.	1	1	1	8	6¼	1	1	1	1			
	Cost in dollars	.52	.52	.52	3.92	3.59	.52	.52	.52	.52			
Night watch	Hrs.	23	23	23	23	23	23	23	23				
	Cost in dollars	8.78	8.78	8.78	8.78	8.78	8.78	8.78	8.78				
Operating Engineer	Hrs.	10½	10½	10½	5	0	10½	10½	10½				
	Cost in dollars	5.46	5.46	5.46	2.60	0	5.46	5.46	5.46				
Assistant Engineer	Hrs.	3	3	3	0	0	3	3					
	Cost in dollars	1.95	1.95	1.95	0	0	1.95	1.95					
R.R.R.P.P.	Hrs.	2	11	4	3	0	0						
	Cost in Dollars	1.20	6.55	2.40	1.95	0	0						
R.F.R. Misc.	Hrs.	13	0	12	6								
	Cost in dollars	7.75	0	7.10	3.50								
M.R. Misc.	Hrs.	0	0	0									
	Cost in dollars	0	0	0									
R.E.R. B.& F.	Hrs.												
	Cost in dollars												
Construction work													
Live steam heat on days, hrs.													
Live steam heat on nights, hrs.													

tween grate and shell being only 30 in. Indiana mine run coal is used.

Moisture content is found by drying a sample of coal at a temperature of 140 deg. F. for 5 hr. and then weighing it on our sampling scale, which is sensitive. This is not according to Hoyle but, as we do it the same way every time, it is sufficiently accurate, to half a gram, as a means of comparing one coal with another. If we had a method of getting the heat value of the coal as well as the combustible lost with the ash, it

would help us much but small plants are handicapped in this respect and usually guess as to this item or take the mine operators' word for it. As it is human nature to put the best foot forward, this method is inaccurate.

Table I indicates a few of the high points of an evaporation test made on these boilers by Purdue University engineers, during which Indiana number 4, mine-run coal was fired. This coal had a heating value, as fired, of 11,103 B.t.u., a moisture content of 7.41 per cent and an ash content of 9.63 per cent. The actual evaporation per pound of coal as fired was 7.64; that, per pound of dry coal, 8.87. Boiler rating developed was 79.3 per cent with an overall efficiency of 69.6 per cent and steam quality 98 per cent. The equivalent evaporation per pound of coal fired was 7.96 lb. and with coal costing $3.90 a ton, this brings the cost for fuel alone per thousand pounds of steam evaporated to 24.36 cents.

Off-Power Steam Requirement Increases Cost

Maintenance of steam pressure, 24 hr. a day during the entire year, because of insurance requirements and for other reasons, while power is required only five 9-hr. days a week, is the most unsatisfactory feature of this plant. This makes our standby costs high, as otherwise we could bank the fires at night, let them go

TABLE II. SUMMARY OF COSTS FOR COMPARISON AND ANALYSIS

SUMMARY OF POWER DEPARTMENT OPERATIONS JANUARY 1928

Evaporation, Day, pounds		4,490,880	coal tons 305		$ 1195.53
" " " Night, "		1,768,300	" " 155		582.00
			Totals 460		$ 1777.53
Boiler Room Help (Day)	Hrs.	805		$ 373.00	
Watchmen "	"	90		45.00	
" " (Night)	"	715		272.00	
Operating Engr. (Day)	"	246		128.00	
Assistant "	"	77		50.00	
R.E.R. P.P.	"	45-1/2		27.47	
R.E.R. Miscellaneous	"	310		184.59	
R.E.R. B & F	"	4		2.40	
M.R. Misc.	"	7		4.25	
Construction	"	30		15.00	
	Hrs.	2367		$1104.71	
	Total tons coal 460			1777.53	
				$2882.24	

Live Steam Heat Day 76 Hours
" " " Night 188 Hours

out Friday evenings and start steam again Monday mornings, especially during the non-heating season. We estimate that the exhaust steam is worth at least $18 a day for the 9 hr. that the engine runs during the heating season. Some of the pump exhaust is used the entire year for drying purposes and for heating water. Of course that old standby, the steam engine indicator, is a part of the equipment and is used as often as necessary.

At this place the engineer has many things to look after outside of the power plant. The labor items pertaining to the power plant are listed under the heads of boiler room help, operating engineer, a part of the assistant engineer's time; under the heading R.E.R.-P.P. comes maintenance of anything that has steam in it or is operated by steam; while R.E.R. refers to maintenance work on all other piping systems and M.R. refers to repairs to industrial furnaces. New work is given a construction number. The cards labeled A, B, C, Fig. 2 are tacked on the wall near various pieces of apparatus as a record indicating when the work was done. The daily record and monthly summary hardly need explanation. A copy of the monthly summary is

Boiler Pump Valve Changes	Heater Cleaned	Air Compressor Valves Ground
1927	1927	
1-22	1-22	1-25
3-10	3-10	3-20
5-15	5-1	5-15
A	B	C

FIG. 2. RECORD CARDS TO SHOW DATES OF UPKEEP WORK

presented to the manager for his inspection at the end of each month.

It would be beneficial to have steam meters on the process and steam pump lines and we are optimistic enough to think we will get them—some day.

Reconstruction of the American Engineering Standards Committee to keep pace with the growth of the industrial standardization movement in the United States is now under way, according to an announcement by the Committee. The principal features of the reconstruction are the definite federation of national organizations, under the name American Standards Association, in such a way that trade associations interested in standardization may more readily join in the direction of the movement; placing the technical work of approving standards in a Standards Council; concentrating administrative and financial responsibility in a Board of Directors composed of twelve industrial executives. Further details can be obtained from the Secretary of the Committee, 29 West 39th St., New York City.

At the Collieries of the Lothringen Bergbau Gesellschaft at Gerthe, near Bochum, Germany, a high-pressure steam power plant has recently been completed. The installation includes six Hanomag tubular boilers, each with a heating surface of 6458 sq. ft. and a superheating surface of 4950 sq. ft. They are designed to generate steam at a pressure of 28 atmospheres (410 lb. per sq. in.) and a temperature of 470 deg. C. (878 deg. F.). Four of the boilers are fired by pulverized coal and two by pulverized coal and gas. As a reserve for emergencies, a Ruths steam accumulator of 4230-cu. ft. capacity has been installed. The plant supplies steam to two 10,000-kw. turbine-generators and one 1250-kw. unit.

Production and Utilization of Compressed Air

PART II.* MOST POWER PLANTS HAVE A COMPRESSED AIR SUPPLY, BUT FEW MAKE FULL USE OF THE MANY INEXPENSIVE COMPRESSED AIR DEVICES AVAILABLE

TO ATTEMPT a complete description, or even enumeration, of the many useful and novel uses of compressed air and the devices that have been developed by different manufacturers would require many pages. A number of these devices are shown in Fig. 1.

Paint sprays could be used to advantage in many power plants, and one type of spray for this purpose is shown in Fig. 1A. This form of painting has practically revolutionized industrial and manufacturing painting with a great money saving and higher quality work. One man can do from two to six times as much work as he could with a brush and be assured of a smooth, uniform finish without sags or runs, streaks or thin spots, whether the surface be large or small, flat or irregular.

An elaborately carved or irregular piece of work can be finished in approximately the same time, and with the same degree of uniformity as a flat panel of the same area. Paints, fillers, enamels, shellacs, varnishes, lacquers and undercoats can be applied to wood products and lacquers, fillers, paints, surfacers, japans, enamels, asphaltum, bronzes and other material to metal surfaces with the minimum time and expense.

Cleaning tools are always of use, and a number of these are shown in Fig. 1. Figure 1-B is a rotary air-driven wire brush for cleaning flat surfaces, Fig. 1-C illustrates the use of a rotary air-driven boiler tube cleaner while Fig. 1-L is another type of tube cleaner. When using 100 lb. air, the volume requirements of these cleaners range from 15 c.f.m. for the small 2-in. tube size, to a maximum of 50 c.f.m. with larger sizes used for 6-in. tubes or flues. They are effective in removing scale from either the inside or outside of the tubes. Soot blowing by compressed air also offers advantages in high pressure plants and a complete description, with costs, of such a system was published in the March 15, 1928, issue, page 349.

CLEANING DEVICES ARE NUMEROUS

One of the most common uses of compressed air around the plant is for blowing dust and dirt from motors and other pieces of equipment. Usually a short ¼ or ⅛-in. nipple with a small globe valve is used for this service. Figure 1-H shows a small valve especially designed for this service to give the maximum jet velocity and prevent leakage when not in service. The valve is opened by pressing lightly on the button of the valve with the thumb. Another type, Fig. 1-I, utilizes the high-pressure jet as an injector to draw in the surrounding air and give increased volume. Figure 1-J is built for the same service with a pistol grip and comes equipped with a cleaning brush attachment, Fig. 1-K, for use where the dust adheres to the surface so closely that air alone will not remove it.

Condenser tube cleaning is another use to which compressed air can be put. A gun for shooting rubber plugs through the tubes is shown in Fig. 1-E. This method of cleaning tubes is cheap and effective and at the present time is probably the most popular method in use. Manhole covers are removed, plugs placed in the ends of the tubes, the gun shown in Fig. 1-E inserted

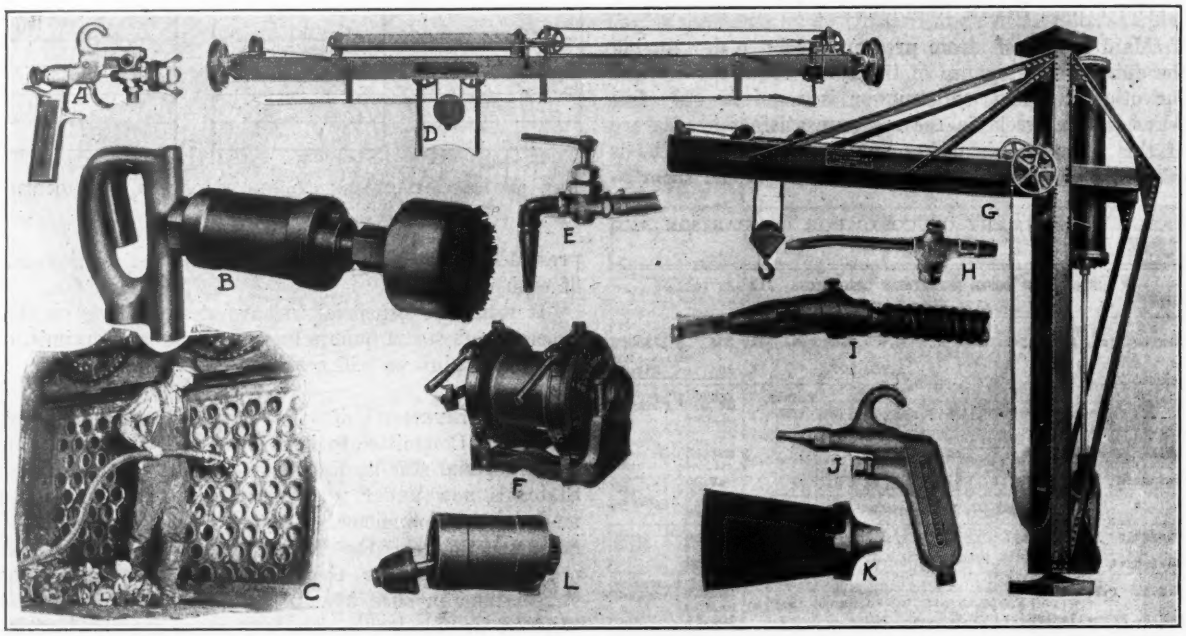


FIG. 1. A FEW COMPRESSED AIR DEVICES THAT ARE AVAILABLE

*Part I of this article appeared on page 729, July 1 issue.

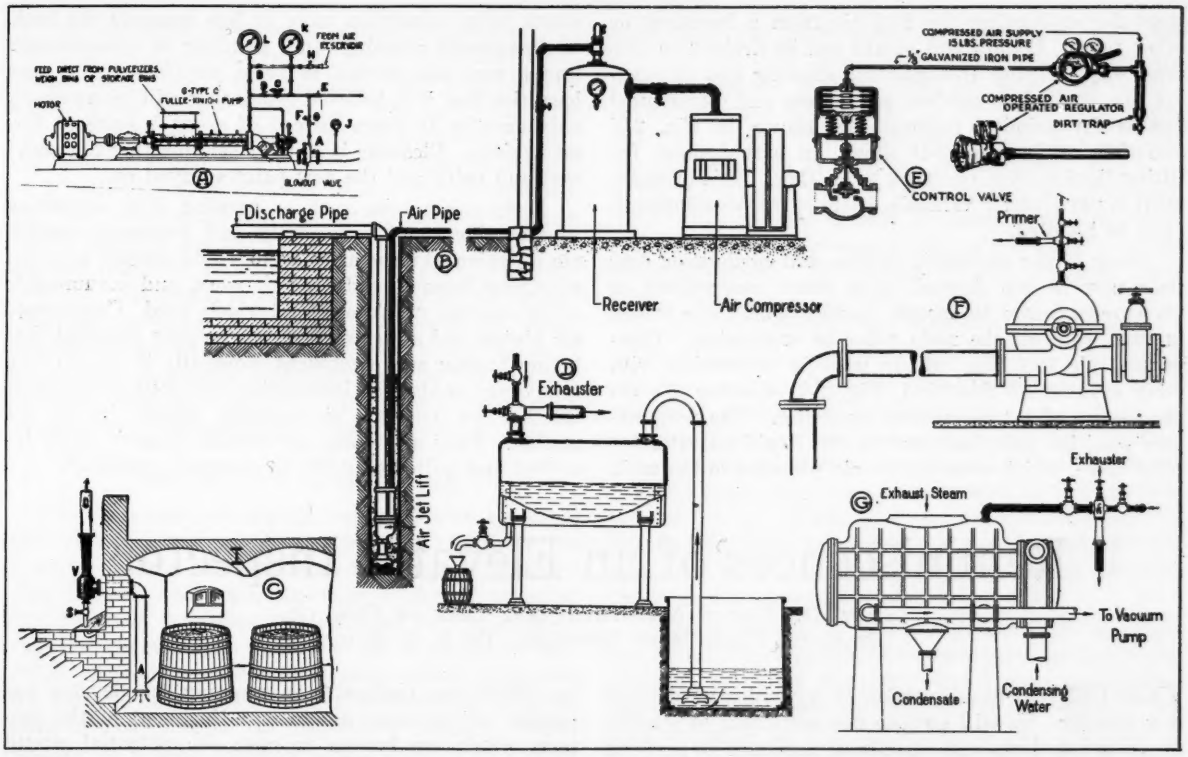


FIG. 2. PIPING ARRANGEMENTS OF A FEW USEFUL POWER PLANT COMPRESSED AIR APPLICATIONS

and the air turned on, forcing the plug through the tube and scraping the dirt and loose scale before it.

Hoists and cranes are always of service. The low head hoist, Fig. 1-D, and the jib boom type, Fig. 1-G, are operated by air cylinders, the load that can be lifted and the distance traveled being a function of the air pressure, cylinder diameter and length, and pulley arrangement. Another type of hoist particularly suitable for portable use is shown in Fig. 1-F. At 50 lb. pressure this hoist will lift 2000 lb. at a lifting speed of 35 ft. per min. Corresponding speeds for 1600, 1200, 800 and 400 lb. with 50 lb. pressure at the hoist are 70, 103, 135, 167 ft. per min.

Compressed air is used for the transport of pulverized coal, one form of pump being shown in Fig. 2-A. But a fraction of the air needed for combustion is used, the purpose of the air in this case being to aerate the coal so that the screw can force it through the pipe without excessive friction.

Air lifts, in which compressed air is used for pumping, are used extensively and have been widely adapted for many chemicals, as well as water. A diagrammatic arrangement of the equipment necessary is shown in Fig. 2-B.

Automatic Devices Can Be Adapted to Air Operation

Exhausters are one of the oldest compressed air devices and can be applied to the solution of many power plant problems. Figure 2-C shows an arrange-

FIG. 3. COMPRESSED AIR IS USED AT KEOKUK DAM TO KEEP THE ICE FROM FORMING IN FRONT OF THE GATES

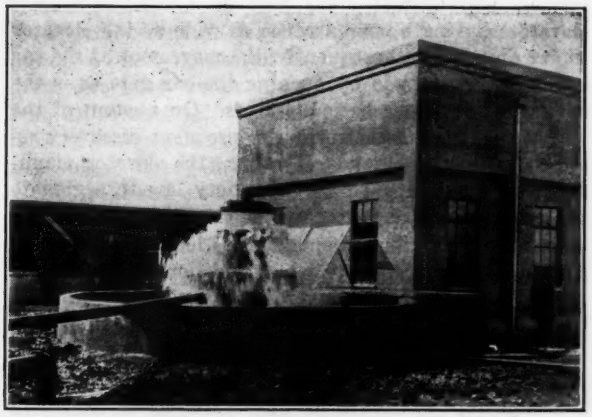


FIG. 4. A LARGE AIR LIFT IN OPERATION SUPPLYING WATER FOR A CITY WATER SYSTEM

ment for exhausting the foul air from a basement or other room. Cellars and sumps can be drained in this same way. Piping arrangements showing how exhausters are applied to surface condensers and centrifugal pumps for priming purposes are shown in Fig. 2-F and 2-G, while Fig. 2-D shows an arrangement for lifting liquids from one tank to another. This arrangement is particularly valuable where corrosive substances must be handled.

Many of the automatic devices and combustion controls now in use depend upon some temperature or pressure indicator to operate a small pilot valve which, in turn, controls the main valve or mechanism. Compressed air has been widely used in connection with relay systems of this kind, Fig. 2-E showing the arrangement of a temperature controller. The temperature sensitive bulb immersed in hot liquid operates the pilot valve, which controls the air pressure to the main steam valve, admitting more or less steam to the tank.

Pneumatic cleaning and painting of transmission line towers has proven to be so satisfactory in some localities that it is believed repainting will be necessary only once in 10 years instead of every 5 years as formerly done. Cleaning is done by sandblasting to remove rust and paint and the new paint sprayed on.

Many other uses, such as blowing flues, operating innumerable small tools, drills and hammers, overfire air injection, the use of refractory and cement guns for repairing furnaces and concrete work, and innumerable other uses are well known and widely used. Compressed air piping and systems are so universally installed that before buying new equipment, especially if it is to be a temporary or standby installation, it is well to determine whether or not an air-operated device is on the market. They are cheap, serviceable, rugged, easily installed and quite adaptable to changed conditions.

Reminiscences of an Elevator Inspector

PART III. FAULTY ADJUSTMENT AND LACK OF CARE OF INTERLOCKS CAUSE MANY TROUBLES. BY S. H. SAMUELS

RETURNING to our subject of correction of elevator troubles, we will go into the correction of specific faults in interlocks and equipment necessary to perform the proper interlocking function since it was previously outlined that these faults must be remedied immediately so as to maintain the advantages enumerated above.

Interlocks of an automatic freight elevator got out of order and were shorted out of the circuit one at a time by the engineer as they gave trouble. Instead of shorting out the last troublesome lock in this similar manner, the engineer opened the lock circuit at the control board. Immediately the emergency stop button was rendered useless and there was no way of stopping the elevator from the car until it had reached the destination to which it had been called or sent—although it might not even stop at the destination if something else got out of order.

EMERGENCY STOP CIRCUIT HAD TO BE SEGREGATED

In that state, the law exempted the use of a collapsible and contacted car gate on automatic freight elevators having a car entrance as wide as the elevator under discussion, consequently, the movement of the car could not be stopped by opening the car gate as is the case with other automatic elevators. On account of the engineer's latest maneuver and consequent discovery regarding the emergency stop button, the elevator manufacturer was compelled by the safety law to segregate the emergency stop circuit from the other circuits.

At the same time a contract was let to place all the interlocks in first class working condition, which repairs might have otherwise lingered for several months or until an inspection was made by the state. During this interim, many things could have happened simply because the engineer could not find time to accomplish a thorough repair when a lock gave trouble or to call in an outside elevator company to do the work.

Another instance of a defective emergency stop button which was ineffective in stopping the elevator was because of improper design or adjustment of the contacts which are broken to open the potential circuit when the emergency stop button is pressed. An arc was drawn between the contacts when this button was pressed to stop the movement of the car which permitted the car to continue in motion because the arc thus formed maintained a complete electrical circuit. The heat from this arc melted the composition of which the button was made and further incapacitated its use.

INTERLOCK BECOMES GROUNDED ACCIDENTALLY

It was desired to get on top of the automatic elevator and while shorting out the interlock at its exposed terminals, one of these terminals was accidentally grounded. The elevator could not then be operated for the potential circuit remained open and the motor circuit opened because of the potential switch dropping out, although the interlock wherein the ground was made showed no defect when tested. The engineer stated that the car could be operated by blocking up the potential switch, although the interlocks were ineffective. In this instance, the car could be stopped by pressing the emergency stop button, showing that it was connected properly through a separate circuit as required. The potential fuses behind the control board were wired up at the time of test.

Because the lock at which the accidental ground occurred showed absolutely no defect, a cursory examination of the other locks was made without noticing that any of them were defective. The various control circuits on the board were tested and found in good condition. After remaining in a quandary for a few moments it was finally decided to make a thorough electrical test of each interlock. As is so many times the case, the very last lock tested proved to be defective and one terminal tested was grounded.

Upon taking this lock apart it was discovered that

the stranded wire where soldered into the terminal was burnt off and that several of the strands had been touching the metal case of the interlock. This lock had evidently given trouble before and was the reason for wiring up the potential fuses behind the control board. The conduit system was thoroughly grounded according to code so that when the accidental ground occurred, the "hot" side of the interlock circuit made a complete circuit through ground to the grounded terminal of this last interlock, causing the wire to burn off at the terminal. Altogether it took 3 hr. to test out, repair and place this elevator in proper operating condition, while, had there been an emergency release in the car as in the case of a manually controlled elevator, the engineer no doubt would have resorted to plugging it rather than "waste time" accomplishing a thorough repair.

Poor Contacts Give Trouble

Some interlock circuits are equipped with an auxiliary relay which completes the potential circuit of the control. When a hatchway door is open, this auxiliary relay is open and when the door is closed, potential circuit contact is made. The engineer had resorted to plugging the emergency release on a manually controlled elevator because this elevator would sometimes stop between floors and could not be run again until the operator had pressed the emergency release. When stopping at a floor, the door would have to be opened and closed several times before the elevator operated.

When properly analyzed, the seat of the trouble should have been obvious, but was looked for at other locations. The commutator was sand-papered, brushes rotated and changed, and control contacts smoothed without avail. The auxiliary contacting relay had two copper-to-carbon contacts which closed both legs of the potential circuit. Perfect contact was not always made on both contacts at the same time. The two carbons were sawed off so as to bring the contacting arm close to the magnet core without touching, to obtain as strong a magnetic pull as possible. The adjusting screw was so regulated that the magnetic pull would not be exerted at too great a distance from the magnet core when the contactors were open, thus giving positive action to this device.

Spring Strip Improves Action of Contacts

Then the contacting arm was removed and a piece of spring copper strip bent U shape, with holes cut out, inserted on both screws of the copper contactors between the contactors and insulated from their arm. These contactors were adjusted so as to have a slight movement independent of each other, thus giving perfect contact with the carbons at all times. The plug was removed from the emergency release device and a glass inserted in its frame, no further trouble being experienced.

Trouble was traced to a single pole contacting relay, when an elevator was operated with any hatchway door open, by pressing the emergency release button. Upon removing pressure from this release, the elevator continued in motion until stopped with the car controller. The emergency release button had to be pressed to operate the car again or until the opened hatchway door was closed. It was found that, when the emergency button was pressed and released again under the above conditions, the relay contactor would close and then draw an arc upon opening when pressure was removed from the release button. This arc would maintain a closed potential circuit and the car would continue to run full speed. The contacting carbon of this relay was sawed off so as to bring its contacting arm close to the magnet core without touching and the adjustment screw was regulated so that the arm would drop away just a sufficient distance to extinguish any arc that might be formed. The elevator operated properly thereafter.

Sequence Relay Was Wrongly Connected

Trouble with a sequence relay was experienced and took much effort and time to trace out and correct. This relay was effective in performing its proper functions only when the car was proceeding in the up direction. When traced out, it was found that the "hot" leg to the relay terminals was wrongly connected to the first contact of the up direction of the car controller, at the terminal junction box under the car, instead of being connected to the contacting arm terminal of the controller in this junction box.

Another instance of faulty sequence relay operation was found to be a matter of adjustment of magnetic gap (between contactor and core) and a loose or differing resistance connection in some of the interlocks. The poor operation of this device, which was overcome by adjustment of the relay and going over all interlock connections, was caused by the improper functioning of this sequence relay when the car controller handle was operated before the door was closed. This faulty operation occurring at only some and not all of the floors.

(To be concluded.)

Limitations on Attractive-Nuisance Doctrine

By Leslie Childs

AS A GENERAL proposition of law, the maintenance of a power line accessible and attractive to children, at any point on its course, may render its owner liable for injury caused thereby. There is nothing new in this statement, and power plant and line executives are, of course, familiar with its application.

To this doctrine may be added, however, that a power company is not an insurer of the safety of children who may under every conceivable circumstance come in contact with its line. In other words, the doctrine of "attractive nuisance" has no application where a power company has exercised every reasonable care and a child suffers injury by coming in contact with a power wire, solely as a result of its activities as a trespasser.

Of course the facts of each case of this kind will govern the outcome and general rules are of little value in covering the subject; however, as an example of the application of the rule outlined, the recent Missouri case of Howard v. St. Joseph Transmission Co., 289 S. W. 597, may be reviewed with profit.

In this case the defendant's power line ran along a public highway and at a certain point a stream flowed

close to the line. The stream was frequented by boys who went there to swim and fish. At this point, the power poles were about 12 in. in diameter and first carried two telephone wires on brackets nailed to the poles about 2 ft. 5 in. apart. About 2 ft. 2 in. above the highest telephone bracket was placed a two-pronged metal bar which supported three high-power wires.

The lower telephone bracket was about 8 ft. 6 in. from the ground, and the metal bar supporting the high power wires was at its lowest point 13 ft. 1 in. from the ground. The power line carries 11,000 v. and the poles were free from steps, spikes, ladders or other means of climbing them, until the first telephone bracket was reached.

On the day of the accident out of which this action grew, plaintiff, a boy 9 yr. of age, was fishing in the stream near the power line. His hook and line became entangled in the power line and he climbed the pole to loosen them. Here he came in contact with the high voltage wires and as a result of burns received it became necessary to amputate his leg and arm.

The Record Reviewed

On this state of facts, the instant action was brought against the defendant for damages in the sum of $100,000. The complaint was grounded on the "attractive nuisance" doctrine, by allegations that the defendant maintained "an unattractive, dangerous instrumentality in or near an attractive environment." The trial court dismissed the complaint on the ground that the facts alleged did not show liability on the part of the defendant. Plaintiff appealed to the Supreme Court of Missouri and here, in reviewing the record, it was, among other things, said:

"It is apparent that there were no convenient pegs, or ladder, upon the sides or circumference of the pole, by which plaintiff could have readily or easily climbed to the metal bar, near the top of the pole, which supported the electric wires. The lower of the two brackets or pegs supporting the telephone signal wires was approximately 8 ft. above the surface of the ground and it is obvious that a 9-yr.-old boy could not have reached with his extended arms the lower peg and thereby climbed to the top of the pole; the only way by which he could have ascended the pole was by 'shinning' up the pole at least to a point in the circumference where he could reach upwards with his arms and grasp the lower bracket or peg with his extended fingers.

"No appliance fastened to the pole could be reasonably deemed an implied invitation, even to a child of tender years, to climb the pole, and the charged and uninsulated electric wires were some 13 ft. or more above the surface of the ground, well beyond the reach of any person, adult or child, and endangering no one who was in a place of safety upon the ground. * * *"

Following the foregoing review of the record, the court, after examining the authorities in an exhaustive manner, stated its conclusions on the whole case as follows:

"Were we to hold the respondent (defendant, power company) liable for the negligence under the pleaded facts in the instant case, it would mean that an electric company is an absolute insurer of the safety of children under almost every possible or conceivable circumstance, regardless of whether the company has used reasonable, or the very highest, care in placing its wires out of reach of those who would ordinarily be in no possible danger of coming in contact with them, and regardless of whether the child is injured solely by reason of being a trespasser upon the pole of the electric company, without being lured or invited upon the pole because of any of its attractive or convenient appliances or fixtures.

"Such a holding would be contrary to every sense of justice, fairness and right, and would be violative of the long-established principles of the law of negligence as announced in this, and the great majority of foreign jurisdictions. The mere fact of an accident and resultant injury does not, as a general rule, make out a prima facie case of negligence. * * *

"Regrettable as appellant's (plaintiff in lower court) misfortune may be, and grievous as his injuries are, his misfortune was caused solely by his own negligence or heedless conduct, while he was a trespasser (nothing less) on respondent's pole, without any invitation, expressed or implied, to be there, and when he was in a place where he had no lawful right to be.

"Having repeatedly and decisively ruled that the 'attractive nuisance' doctrine is not to be extended or enlarged beyond the principle of the turntable cases, we cannot, under the pleaded facts of this case, find and hold the respondent to have been guilty of any actionable negligence, or, indeed, of any negligence whatever. * * * It follows that the judgment * * * was right and must accordingly be affirmed."

Conclusion

The foregoing case was carefully reasoned by the court after an exhaustive review of the authorities and its holding is believed to be in accord with the weight of authority. This authority holds that, while a power company is held to a high degree of care, in protecting persons from contact with its wires, it is not an insurer of the safety of such persons under all circumstances.

Of course, since each case of this character must necessarily be decided in the light of its facts and circumstances, the subject cannot be covered by a general rule. The Missouri case reviewed is not put forward as announcing any such rule; however, it does constitute a clear cut presentation of judicial reasoning which limits the application of the doctrine of "attractive nuisance," in situations of this kind, and is one of the strongest cases the books contain on this much litigated subject.

To eliminate confusion in regard to definitions of terms and symbols used in the science of heat transmission, the committee on heat transmission of the National Research Council has appointed a sub-committee on definitions headed by E. F. Mueller of the Bureau of Standards. This subcommittee has submitted a report which will be transmitted to the American Engineering Standards Committee for acceptance. Further details of the undertaking may be obtained from W. V. A. Kemp, Director, Committee on Heat Transmission, National Research Council, 40 W. 40th St., New York City.

Obsolescence Remote with Diesel Engines

In the June 15 issue, the editorial entitled "Obsolescence of Power Plant Equipment" is right to the point. It is fruitless for engineers to argue as to how much depreciation should be charged for a certain piece of machinery if improvements in the art are likely to cause the equipment to be replaced long before it is worn out. This is particularly true of steam power plant apparatus, where the advance in efficiency has been quite rapid for a long time.

Central station engineers engaged in designing new power plants have clearly recognized the importance of obsolescence. When new and efficient generating capacity is being added to an existing system, they plan for its use on base load for only a limited period. After that, the projected schedule calls for peak load operation only, since by that time still more efficient equipment will probably have been installed and will then be carrying the base load. Operating records of about 200 large steam turbines published by the National Electric Light Association justify these loading predictions. They show that the turbines in their third year of operation ran an average of 73 per cent of the total time at an average load of 69 per cent, while those in their tenth year ran only 56 per cent of the time at an average load of 62 per cent.

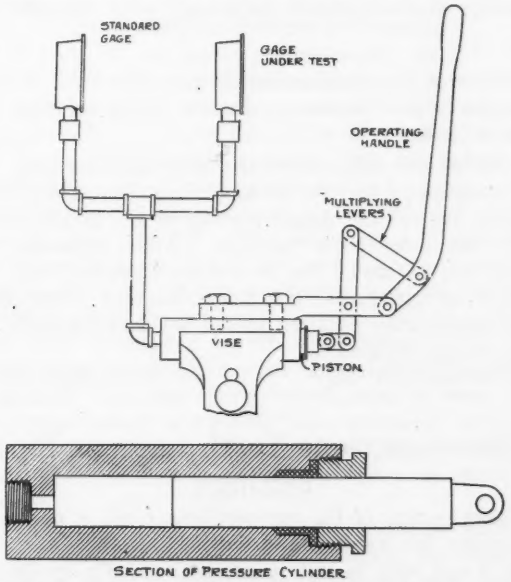
Generally speaking, the obsolescence factor today is one of great importance but an interesting exception appears to exist in the case of the Diesel engine. Since the first Diesels were put into use in this country about 25 yr. ago, there has been little change in their combustion processes. Steam power plants have been rapidly developed in the direction of better fuel efficiency by employing higher steam pressures, more superheat, bleeding systems and so forth. These developments, by increasing the efficiency of the ideal cycle, naturally improved the fuel consumption. Diesel engine development, however, has proceeded along entirely different lines. The ideal efficiency of the Diesel cycle depends upon the compression pressure and the cutoff ratio, and these have remained practically unchanged since the earliest days. Almost at the very beginning, the fuel was injected and distributed in the cylinders in a well-atomized state, and excellent combustion was obtained. As a result, even the earliest Diesel engines secured so low a fuel consumption that the subsequent development has not achieved much improvement in this particular. The modern Diesel has advanced far in the direction of greater sturdiness, simplicity and reliability but its fuel efficiency has improved but little.

That is why the obsolescence factor appears to be of little consequence with the Diesel engine. The urge of better fuel economy, which is the paramount cause for replacing steam equipment, does not exist in the case of the Diesel. True, the modern Diesel engine is not so sensitive as earlier designs and its maintenance costs are much lower but these factors are not of sufficient importance to justify the replacement of the old engines by new ones. This is proved by the life history of some of the first engines installed in this country. Their wearing parts, such as pistons, cylinders, valves and bearings have been replaced from time to time as required but the engines are still in daily operation and apparently serving their owners in an economical manner. Further confirmation is apparent in the report of a manufacturer who had installed 265 Diesel engines in central stations in a period of 20 yr.; at the time of the survey 98.88 per cent of the horsepower was still in service.

New York City. Edgar J. Kates.

Calibration of Pressure Gages

Pressure gages for steam, air and water are subject to variations which, if not corrected, result in incorrect determinations and perhaps in danger to equipment or



HOMEMADE DEVICE SERVES WELL FOR CALIBRATING GAGES

operators. Means for testing and checking such gages should be available in the average plant.

In one plant, the equipment necessary to accomplish this purpose, made entirely of parts found about the plant, was constructed by mechanics in regular employ as shown in the sketch.

Details, made mainly of pipe and fittings, were used in conjunction with a manually operated hydraulic cylinder of sufficient strength to supply any desired degree of pressure. This cylinder was made from a steel block which could be quickly and easily clamped in a vise. A plunger was snugly fitted to this cylinder and leather packing employed to prevent leakage of fluid.

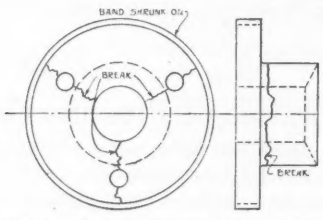
Two similar gage supports with connections are provided so as to establish equal pressure on both gages. A handle, fitted with multiple levers, affords high pressure in the fixture. Grease is used for convenience but, in a cold plant, a heavy oil would make a good substitute.

In making the calibration, the pipe lines are first filled with grease or oil and the gages screwed down on their supports.

Washington, D. C. G. A. LUERS.

Shrunk Iron Band Repairs Gland

ONE NIGHT, when the peak load was passed, the nuts on the gland of our 14 by 36-in. Corliss engine worked off and with a roar the gland blew off and broke in four pieces, as shown in the sketch. The direct cause of the



BROKEN FLANGE PARTS OF GLAND ARE DRAWN TOGETHER BY SHRUNK-ON IRON BAND

trouble was the misalinement of the engine which gave a slight lateral movement to the piston, causing the nuts to loosen.

Our second unit carried the load until morning. In the meantime, I had the blacksmith shrink a heavy band of iron around the flange portion of the gland, which drew the three parts together. After replacing the gland on the studs, the nuts were tightened and the cylindrical part forced into the stuffing-box. The gland thus temporarily repaired served for many months before it was replaced.

Pleasant Hill, Mo. G. H. BROUGH.

Oxy-Acetylene Torch Loosens Pipe Fittings

APPLICATION of the oxy-acetylene torch is no longer a novelty for welding and cutting but the other uses that it can well be put to are limited only by the ingenuity of the engineer.

Recently, I saw some pipe fitters at work making up a 16-in. flanged spool. One of the flanges lacked ½ in. of screwing up far enough. Ordinarily, this would have meant removing the flange and taking it or the pipe to the machine shop to have the threads eased in a lathe. The plan adopted was to heat that part of the pipe inside the flange with two torches for a few minutes, then the pipe was allowed to cool, the cooling being hastened with water.

As a result, the flange, which before could not be moved by three men and a 12-ft. lever, could now be freely turned by hand. It was, therefore, screwed on the required amount and a slight peening insured its tightness.

Heating the pipe caused it to expand but the flange prevented it from increasing its diameter, so it found relief by compressing itself, and when again it became cold it had contracted enough to make the flange loose.

Flanges which are rusted or cemented on can by this means be readily removed. Heating the ends of boiler or other tubes that are tightly expanded in tube plates can, in this manner, be a means for loosening them.

Long Beach, Calif. E. J. JORDAN.

Vibration Affects Operation of Instruments

DID YOU EVER hear a thud—thud—thud in the crosshead and discover that it was the carpenter repairing the roof, instead of the poor old crosshead? Did you ever hear your poor old Lizzie suddenly develop a new thump—thump—thump and then discover that your passenger was drumming on the door panel? Sounds are sometimes extremely deceiving, even to an engineer.

In a certain plant containing both steam and hydraulic turbines, a system of flow meters was installed and the system functioned remarkably well. After a while, an electrically-operated recording thermometer was installed to chart the temperature of a certain room where a few hundred women were employed. When the temperature of this room was right, operation of this particular heating system was satisfactory.

This recording thermometer was ordered set up and put in operation without any outside assistance, which was a perfectly proper procedure but the company furnishing the instrument never even wrote to inquire whether the apparatus was working satisfactorily or not or had even reached its destination. The man in charge, slow to anger, began to warm up a trifle, then when the needle on the instrument started to shimmy one day, he said, "Blank-th'-blankety-blank! Why don't that district representative, who got the credit for selling this piece of junk, drop in to see whether I'm satisfied? I'd sure tell him that I'm not!"

Do you remember how the old geographies represented mountain chains, the hen tracks, as it were? Well, that electric thermometer, was cutting up in a corresponding manner. According to that chart, the heat cycle was changing about as fast as a motion picture. Something had to be done! Would we send for the instrument man? Up to date, he hadn't been very enthusiastic for our acquaintance, so we decided to let the machine continue to play St. Vitus for a short period.

Finally one of the boys said, "One of the machines must be vibrating like the old Nick to make that pointer wiggle so, or else a wire is loose." We didn't find a wire loose or we didn't find a turbine vibrating unduly. Then some one suggested that the hydraulic

units were being operated considerably and that perhaps the water discharge from the draft tubes, about 42 ft. directly under the instrument board, might be causing the trouble but an examination failed to show that this was the source of the vibration.

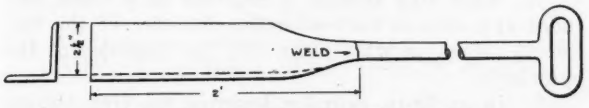
At last, after the disturbing phenomenon had gone on for several weeks, an operator found a small pump operating out of balance because of overspeeding. This pump was setting up a vibration which was transmitted through piping and hangers to the section of concrete flooring to which the instrument board was fastened. Although the flow meters operated on an entirely different principle and were stable enough to withstand the vibration, the thermometer, whose nervous system was more delicate, was irritated beyond reason. After correcting the disturbance, the graph obtained was found to be a clear distinct line, and the aforementioned mountain chain has passed from view, we hope, forever. All of which goes to show that sometimes the small things in this life cause the greatest worries.

Incidentally, if our extremely slow sales representative had called around, he might have secured a fair sized order. A little service sometimes has a wonderful influence.

Lawrence, Mass. JOSEPH BROWN.

Slice Bar Is Made of Angle Iron

WHEN I was at the Pacific Coast a few months ago, I noticed a fire tool in use which interested me, as the men using it informed me that it served much better



ANGLE IRON STIFFENS SLICE BAR

than the ordinary flat tool. It was formed as shown in sketch by welding a piece of angle iron about 2½ in. inside measure and about 24 in. long to a steel bar of suitable length for the furnace in which it was to be used.

Toronto, Canada. JAMES E. NOBLE.

Second-Hand Boilers Should Be Carefully Inspected

WHAT IS COMMONLY known as a "second-hand" boiler should never be purchased without first giving it a complete and thorough examination. Unless the boiler has a known "pedigree," many assumptions must be made and such assumptions should always be made with a good margin of safety. For instance, if test marks of the boiler maker or rolling mill cannot be found upon the sheets, then assume a tensile strength well below 55,000 lb. per sq. in.

Plate thickness should be determined either by careful measurements of the overlapping plates, or by actually calipering the plates through openings in the boiler, either the openings already there or others or drilled for the purpose and afterwards securely plugged. Ascertain the strength of the longitudinal seams by actually computing the plate and rivet sections and for this purpose, if necessary, remove and afterwards replace with new rivets any that may be imperfect. The curvilinear seams are usually ample to carry the load upon them but it is well to inspect them as to plate and rivet section.

Discover and measure as accurately as possible any wastage of shell plates or heads and, in calculating bursting pressure, use only the thinnest sheet thickness found, for the entire shell. Examine the entire boiler exterior carefully for "signs of weakness" and, whenever such signs are found, persevere in the examination until the causes for such failure have been fully located. Check the holding power of the boiler head braces and make sure that they are sufficient in number, arrangement and length.

Keep a wary and suspicious eye upon the tube sheets of the boiler, especially the rear head. Note well any signs of tube-leakage and of corrosion of the head around the tube-ends. Perhaps the tube-ends may have been reduced to almost paper thickness and when the incrustation from corrosion has been removed from around the tube, it may sometimes be found that the tube sheet has been so destroyed by oxidation that not sufficient metal remains to hold a new set of tubes. Sometimes only a few tube ends will be found with badly corroded tube-sheet surface. Again, nearly the whole boiler head may be wasted away, to a point beyond repair. Watch the heads well, when picking out a secondhand boiler. Also watch out for corroded places in the shell where water has dripped upon the hot metal for months or, perhaps, years.

Indianapolis, Ind. JAMES F. HOBART.

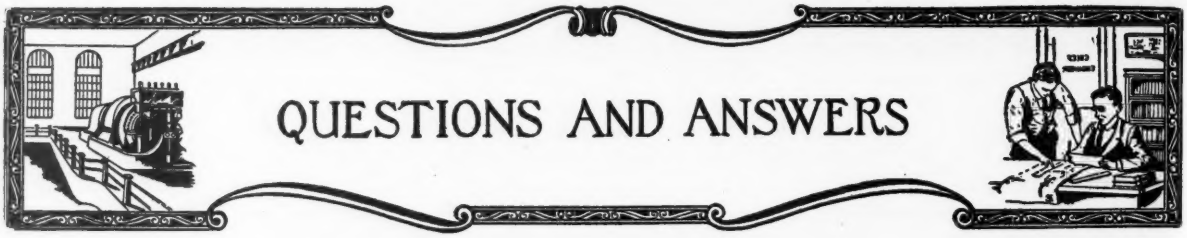
Sheet Aluminum Foil Forms Good Heat Insulator

PROVIDED the air spaces are sufficiently small to prevent formation of convection currents, air is an excellent heat insulator. A new method of employing this characteristic of air is by use of thin sheets of aluminum foil, which, being highly polished, does not radiate or absorb heat as readily as roughened surfaces.

Aluminum is chosen, as it can be obtained in the form of very thin foil. The method of application is first wind one layer of foil around the steam pipe, then some spacer rings of non-conducting material, capable of withstanding the temperature, are placed around the pipe. This is followed by alternate layers of foil and spacer rings until the desired thickness of insulation is secured. Asbestos string, which must be very thin and wound tightly around the pipe, is usually employed for the spacer rings. The foil must also be wound tightly over this to keep the air space as small as possible.

Joints and valves are usually dealt with by winding the foil loosely around them. Although in this case the insulation is not so efficient as in straight pipe insulation, it is more efficient than the methods usually adopted. The principal advantage of this insulation is its light weight, which is about $\frac{1}{10}$ the weight of that of the usual lagging used. Weight of insulation is often a serious consideration where the steam mains are long. Aluminum is also not easily subject to corrosion by air and moisture, making it valuable in the cases of underground steam pipes.

Brentford, England. W. E. WARNER.



Bearings Designed for Accessibility

PLEASE LET ME know what is meant by the following:

1. A marine bearing.
2. A quarter-box bearing on a Corliss engine.

H. K. C.

A. Marine bearings apply to connecting rods in which there is a cap which may be removed by unfastening the two bolts that hold it in place as shown at the right in Fig. 1. They are distinguished from solid and

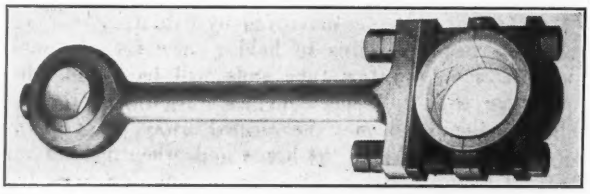


FIG. 1. MARINE BEARING HAS REMOVABLE CAP FOR ACCESSIBILITY

strap-end connecting rods which are not so accessible and they are used particularly in marine practice because of the limited space usually found on shipboard.

2. Quarter boxes are in no way confined to Corliss engine use. In this box, the bearing surface is divided

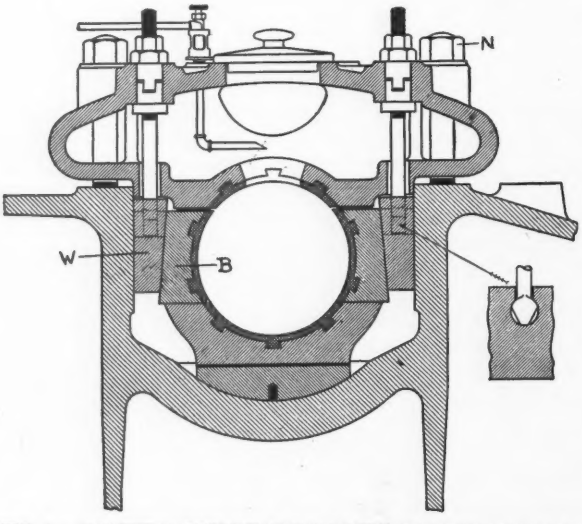


FIG. 2. QUARTER-BOX BEARING MAY BE DISASSEMBLED WITHOUT DISTURBING ALINEMENT OF SHAFT

into four parts as shown in Fig. 2 so that by loosening the adjusting wedges, W, and removing or raising the cap by loosening nuts N, the quarter boxes B, may be removed without taking out the shaft or disturbing the alinement.

How Should Plant Heating Steam Be Charged?

CORRECT determination of cost of steam is desired by one of our readers and, as his question has several angles, it is being laid before our readers for their comments. The statement as it is put is:

"The Cost Department tells the power plant that the cost of steam used for boiler auxiliaries is not used in arriving at the cost of steam delivered to other departments of the plant. To arrive at the true cost of steam, does the cost of steam used in the boiler room not have to be charged to the boiler room? What method would you use in arriving at this cost?"

Piston Rings Designed to Exert Equal Pressure

YOUR ANSWERS to the following questions will be greatly appreciated:

1. What is meant by "tension" in piston rings, and how is it measured?
2. What ring tension is required in a steam cylinder and does it vary with the diameter of the cylinder? If so, in what ratio with the diameter of the cylinder?
3. In an 18-in. cylinder, knowing the ring tension required, how would the thickness of ring and open diameter of ring be determined, width of ring being ⅞ in., for: (a) hammered cast-iron rings? (b) forged steel rings?
4. Is there a general formula that can be used for determining piston ring dimensions, knowing diameter of cylinder, material to be used and required ring tension?

M. S. S.

A. "Tension" would apply to one piece, concentric or eccentric rings and is the stress set up within the ring due to the fact that it is turned large, a piece cut out and then sprung together in order that it may exert a pressure against the cylinder walls. It is measured by the force which is required to close the ring from its free position to the closed position in which it operates in the cylinder. This is generally found by placing the ring on a platform scale in such a way that a point 90 deg. from the joint is resting on the platform, then at a point directly opposite, pressure is applied until the ring gap is closed to the amount that it will be closed when the ring is in its cylinder. The tension is then found by taking the direct reading on the scales and subtracting the weight of the ring.

2. The total tension, as found above, depends upon so many variables that no one figure can be given for the tension required in a steam cylinder. The most satisfactory way is to reduce the total tension to unit pressure in pounds per square inch. This unit pressure

should then bear some relation to the steam pressure in the cylinder and, as the steam pressure decreases as the cylinder diameter increases, it is apparent that the unit pressure of piston rings decreases as the diameter increases.

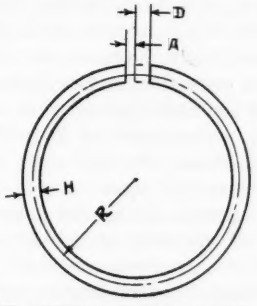
For practical purposes the unit pressure of piston rings may be taken as 1/25 of the steam pressure or from 4 to 6 lb. per sq. in. In terms of total pressure, the unit pressure of a ring is approximately equal to the tension divided by the projected area of the ring.

Stated as a formula, this becomes:

$$P = T \div D C$$

Where P = ring pressure in lb. per sq. in.
T = total ring pressure
D = cylinder diameter in inches
C = ring width in inches

3. For general steam engine practice, it is safe to use cast-iron rings with a radial thickness of 0.03 times the diameter and a free gap opening of 0.1 times the diameter. With an 18-in. ring, the radial thickness is then 0.54 in. and the free gap opening is 1.8 in. This



PROPORTIONS OF PISTON RINGS VARY ACCORDING TO KIND OF MATERIAL AND CONDITIONS OF USE

makes the open diameter 18.573 in., because a gap opening of 1.8 in. means an increase in circumference of 1.8 in. or an increase in diameter of 1.8 divided by 3.1416.

4. No universal formula can be given for rings made of cast iron, because the characteristics of this material are totally different when made under different foundry methods. "Unwin" has a theory on single uniform rings but it is not always reliable. Experience under definite conditions serves better. Unwin's formula will be found in engineer's handbooks. Referring to sketch of concentric ring, one large engine builder uses the following proportions.

A = distance between ends when in cylinder
B = cylinder bore
D = distance ends are sprung when ring is put into cylinder
H = thickness of ring.
R = mean radius of ring when free
$= [B + (D \div P) - H] \div 2$

where P = 3.1416, the ratio between the circumference and diameter.

A pressure of 2½ lb. per sq. in. of ring surface is used. This gives the following formulas:

For cast iron $D = 0.000024\ R^4 \div H^3$
For steel $D = 0.000060 R^4 \div H^3$

The proportion between D and H may be changed to suit conditions. For a cast-iron ring that has to be spread to slide over the outside of the piston, the following proportions are sometimes used:

$$D = B \div 25 \text{ and } H = B \div 30$$

Piston rings are made eccentric in order to exert a more nearly uniform pressure at all points around the ring. Unwin gives proportions of such rings.

Dry Vacuum Pump Operation Under High Demand

ON PAGE 743, July 1 issue, the questions on Condenser Operation have proved of interest to me. In any type of condensing apparatus, the highest point of vacuum is where the vacuum is generated. The vacuum being created in the tube and Venturi of a barometric condenser, a vacuum gage would not show the same at all points.

If any reader who has access to a barometric condenser will tap in a ¼-in. pipe a couple of feet above the hot well, he may be more or less astonished at the gage reading. The trouble with attempting to get a high vacuum with the ordinary piston and valve type pump is due to the resistance offered by the suction valve and spring, which cannot be successfully overcome. Because of this, certain builders have left these parts out and have built what is known as the suction valveless type which works successfully with any possible vacuum.

It is well to remember, however, that a dry air pump is also necessary under these circumstances and that a dry pump of the piston and valve type must have mechanically operated suction valves. Clearances in the dry pump must also be cut to a minimum and for the best operation the flash port should be incorporated.

If N. A. B. has been up for examination, these several little points, I feel sure, are what the examiner has been looking for.

In winter weather, when the water is 35 deg. and the air content in water is low, I have seen a barometric condenser, without auxiliary air remover, pull a vacuum of 29 in. with the barometer at over 30 in.

New York City. JOE BROWN.

Steam Pump Operation

KINDLY let me have information concerning the following:

1. What are "cushion valves" such as are sometimes used on large steam pumps.

2. Describe the best method of packing the pistons in the water end of a steam pump, when using square cotton and rubber packing.

3. Why is it not necessary to counter-bore cylinders of a duplex pump? A. L.

A. "Cushion valves" keep the pump piston from hitting the cylinder head. The heavier moving parts of a large pump have greater inertia than those of small pumps, hence greater precaution against knocking must be taken.

2. Before packing the pump, the duck packing should be soaked in hot water overnight and then cut in rings, with diagonal cuts, to a size that allows a slight opening along the cut when the packing is in place in the box. Stagger the joints of the adjacent rings of packing.

3. Since duplex pumps have liners on the water end, it is not necessary to have these cylinders counterbored.

EDITORIAL COMMENT

American and Foreign Interconnection Systems

Because of the human tendency to believe that the best lies farthest from us, it is quite common to hear the superior ability and achievements of foreign engineers and scientists praised and held up as models for our scientists.

No doubt there is a basis for the feeling but, in spite of this, it is satisfying to know that the International Executive Council of the World Power Conference recommended to all countries the adoption of the far-reaching interconnection of electric systems and the larger distance transmission and interchange of power as developed by the United States.

An appeal to the various countries to facilitate, by all means in their power, the operation of interconnected transmission systems nationally and internationally in accordance with American practice is good evidence that there is at least one phase of power plant engineering in which we excell and which can be held up as a model for others to copy. Furthermore, this is a field in which the credit for both development and accomplishment is strictly American.

Federal Trade Commission Hearings Adjourn for the Summer

With the adjournment of hearings in the investigation by the Federal Trade Commission into the public utilities on July 6, one cannot but feel that, despite the fact that no evidence of criminal or moral wrongdoing on the part of the utilities has been produced, thus far the investigation has done more harm than good. This, probably, is inevitable in any investigation of this kind, which is instigated under the assumption or suspicion that something is wrong. The tendency, in all such cases, is to seek evidence only of a harmful character, to the exclusion of that which denotes good intent and which, if presented would have a mitigating effect. The purpose of the Federal Trade investigation is frankly to produce evidence against the power industry.

We, in the power industry, know that the industry is in a healthy condition and that it has contributed more than anything else to the success and prosperity of the nation. While the Federal Trade Commission has been endeavoring to find out what is wrong with the power industry, the whole world has been trying to find out the reasons for the industrial supremacy of the United States and has reached the inevitable conclusion that it is because of the remarkable development of our power industry. But the public in general does not realize this and is likely to attach undue importance to the evidence relating to exaggerations and blunderings of a few incompetent publicity men whom it was the misfortune of certain utilities to employ.

Since the investigation was inaugurated four months ago, the examiners have been given free access to all the files of all the utility associations and information bureaus. A tremendous amount of testimony has been recorded and, while all of it has been available to the newspapers, the latter have seized upon only isolated and scattered portions of the evidence. This fragmentary evidence presented to the public by the press is naturally not sufficient or of a character to enable any fair-minded person to judge the situation correctly. As a consequence, the industry has been subjected to some unfavorable, if not unjust, publicity.

As stated previously, however, no evidence of malpractice has been unearthed and, while some of the publicity bureaus of the utilities may have exaggerated and blundered in the performance of their offices, no fundamental harm was done. By this time, the utilities will have learned to exercise some care in the selection of their publicity agents. It is the obvious function of the utilities to tell the story of the industry to the public and to protect themselves against the attacks of those who advocate nationalization of industry but this function should be carried out with care and by capable men with a thorough knowledge of the industry —not by over-zealous press agents.

Tempering Coal Before Firing

Reference is made, from time to time, to the necessity and benefits of tempering coal. Tempering, which is the opposite of drying, consists of adding sufficient water to the coal before firing to bring the total moisture content up to a desired value.

Just what this value is depends upon the kind and grade of coal. In general, Illinois and Missouri coals require from 12 to 14 per cent moisture, Kansas coal from 8 to 10 and Arkansas and Oklahoma coal around 7 or 8 per cent moisture to give the best firing results.

Many schemes are used by engineers in different midwestern plants for accomplishing this tempering in the easiest and most uniform manner. Some engineers use a hose but the majority have permanent pipes installed, the water flow being regulated in accordance with the coal demand.

Some of them do the tempering before bringing the coal into the power house, that is, either as it is being reclaimed from storage or in the conveyor itself. Others temper it in the bunkers or, if the bunkers are large, in the spout of the coal larry as it is fed to the stoker hoppers.

The main effect of this tempering is to maintain a uniform fuel bed and it does that by making a more compact and even bed without holes. The additional

moisture increases the stack loss because of the heat carried away by the water vapor. Tests have proved conclusively that the gain in efficiency due to better and more uniform firing and improved distribution of the fuel bed more than offsets the losses and so makes this moisture addition desirable.

It is a case of "put a thief to catch a thief" and, although the practice of deliberately creating losses is to be discouraged, it sometimes pays to stop and think whether the wild hunt and survey for B.t.u. losses may not sometimes be a little over-emphasized. Sometimes, the elimination of a small apparent loss creates a much larger loss which is not so apparent or easy to catch. Steam from the exhaust head always means lost heat but it is not always an undesirable practice. It may cost more to reclaim the heat than it is worth.

What Is Research?

Research has become the shibboleth of modern industry, the password, we are told, that will lead us like the Ephraimites through the ranks of our foes the Gileadites, who, by their strenuous opposition in our respective fields, would prevent us from crossing the Jordan of competition into the land of safety, where large profits lie and where production and consumption are equal. But like the Ephraimites, we may run into trouble on account of a word.

We are like the Ephraimites in that we "cannot frame to pronounce it aright." Some call it r*esearch*, others call it *re*search. Far more important than this, however, is the fact that industry, at least, is often uncertain as to what the word means.

Today industry is confusing two kinds of research: one type which aims to discover scientific truth regardless of its value to any one; a second type, in which the discoveries of pure science are applied by engineers to increase business and meet competition either between the various companies of an industry or between different industries.

It is clear that the fundamental difference is in purpose. The scientific research worker has no concern as to how his discoveries can be used; the industrial research worker has, as his primary purpose, the discovery of something that has financial value.

We are not suggesting that there is anything wrong in the fact that industry carries on research for definite purposes. Much to the contrary, such industrial research is to be commended and among those who commend it most highly are "pure" scientists. What we wish to point out is that industry should not deceive itself into thinking that it is getting one thing when it is really getting something else.

Research in pure science is extremely expensive but it is justified from every economic standpoint. As William M. Jardine recently pointed out, every application of science is dependent on science available to be applied. For example, before the gigantic radio-broadcasting industry could arise, the principles of the vacuum tube had to be enunciated. Before neon-tube electric signs were possible, some one had to discover the gas neon and determine its properties.

Industry as a whole, however, seems to be under the impression that, because it is carrying on a tremendous amount of industrial research, this country naturally leads the world in science. This is not correct, if by science we mean fundamental or "pure" science. As a matter of fact, of the eighty awards of the Nobel prizes in science made since 1900, only five had been won by American scientists up to 1927! Yet it is upon the discoveries of pure science that industry is based. Does it not seem, then, that pure scientific curiosity should be encouraged?

That this encouragement can be given, even in a laboratory devoted to solving specific industrial problems, is proved by the experiences of Dr. Irving Langmuir. Langmuir, after a long period of research which apparently led nowhere, finally arrived at knowledge that made possible the gas-filled tungsten lamp. And all the time, the company that employed him was fully aware of the fact that he did not have the slightest idea where his researches would lead him. Yet he was encouraged to go on, although logically his path was leading away from industrial applications.

For example, Langmuir decides to investigate drawn tungsten wire used in lamps to determine the impurities in the wire in the form of gases. His interest in this is aroused because the methods used for exhausting lamps in the industrial laboratory are far superior to the methods known to scientific research workers. After some experimenting, he finds that the filaments, when heated, seem to give off 7000 times their own volume in gas after a short time. He finally determines that the gas is the result of a reaction between water vapor given off by the glass of the lamp bulb and the tungsten filament. He continues investigating the source of this gas and the effects of putting various gases in the lamps at various pressures. These researches lead him into others concerned with the behavior of tungsten at high temperatures and in the presence of hydrogen. Further researches lead to the discovery that a perfect vacuum would not improve lamps. Finally, after several years of apparently foolish and illogical work, mostly in investigating atomic hydrogen and heated wires, it becomes possible to build the present gas-filled tungsten lamp. How many boards of directors would be willing to wait for such work to be carried out or would consider it a logical procedure?

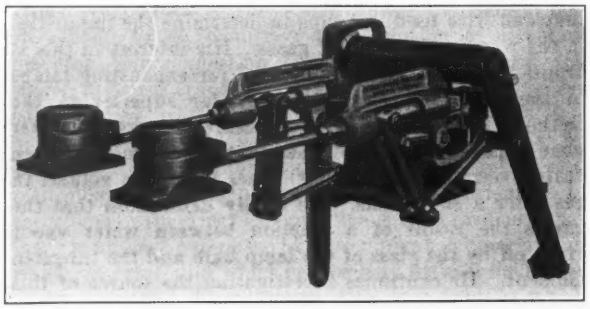
Most industries, it seems, would much rather pursue a more direct course and solve specific problems of their own business. There is nothing wrong in that. But much more fundamental scientific research is needed. Before any practical application of a scientific truth can be made, the truth must be made known "by some disinterested fool," as Poincaré says, "who died poor, who never thought of the useful and yet who had a guide that was not his own caprice."

To a certain type of scientist, curiosity is a greater incentive than the hope of commercially useful results. Fortunately, with proper encouragement, this curiosity itself is a guide that may lead to fundamental discoveries and may solve specific problems in better ways than could have been reached by a direct attack. No industrial laboratory should neglect its work on specific problems. But it should consider also the great merits of the scientific method of search for the truth. And above all, it should understand the distinction between the two so that it will not expect the far-reaching results of the latter when it is paying only for the former.

POWER PLANT ENGINEERING DEVELOPMENTS AND NEWS

Non-Pulsating Valve Motion for Duplex Pumps

PULSATIONS IN DISCHARGE LINES of duplex pumps, even where air chambers are installed, are often encountered by many engineers under conditions in which these pulsations are not desirable. To produce



NON-PULSATING VALVE MOTION AS INSTALLED ON HEAVY-DUTY DUPLEX PUMPS

overlapping of the piston travel of duplex pumps in order to eliminate pulsations caused by jerky discharge, the Volz non-pulsating valve motion, shown in the accompanying illustration, has recently been developed.

This device has two more members on each side than the ordinary duplex motion. These members consist of a floating lever and link. Each valve rod is connected by linkage to both pistons so that while the movement of each valve is actuated by both pistons, the opposite piston causes most of the throw and maintains the two in step. The piston on the same side also acts through the link to the floating lever to cause the overlap in piston travel and to make one piston start as the other nears the finish of its stroke.

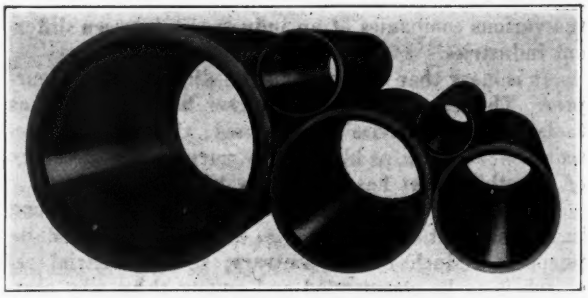
Valve motion is intended to produce an action such that when one piston is at the end of its stroke the other is traveling at full speed and when one piston is decreasing in speed the other is increasing, so that the total displacement is almost the same. The lost motion connection between valve rods and tappets is intended to permit one valve to remain fully open for an interval during which the other valve remains closed. Steam comes through the throttle to the pump in a constant volume. If both ports are open the steam is divided equally between the two pistons. If only one port is open, steam goes to one piston only. In the overlapped position, therefore, the two pistons travel at half speed each, while otherwise one travels at full speed.

It is stated that application of the non-pulsating motion to duplex pumps in actual installations has not only eliminated undesirable vibrations in the lines but, because the fluid being pumped is moving at a constant rate, the effective capacity of the pump is increased, since work is not lost in starting and stopping the load. The device is a product of Volz Engineering Corp., 3732 E. 7th St., Long Beach, Calif.

National Talbot Lined Pipe

ESPECIALLY DESIGNED for use with water distribution systems of various types, such as city water works, high-pressure fire protection systems, industrial plant water systems and the like, National Talbot lined steel pipe has recently been placed on the market.

This pipe has been designed to overcome troubles due to breakage and corrosion and, at the same time, to retain the ductility and strength of steel pipe. The steel pipe is lined with a molten bitumen treated to give the proper physical properties, mixed with a chemically inert filler. This lining is applied to the inside of the pipe by a centrifugal process to give a surface with a smooth mirror-like finish. The lining is designed to be tough, elastic and impervious to water, while it has shown under test great resistance to chemical solutions.



TALBOT LINED PIPE DESIGNED TO PRESENT MIRROR-LIKE SURFACE ON INSIDE OF PIPE

While Talbot lining is especially applicable to pipe intended for carrying water at normal temperatures, it is stated that it will not deform at temperatures up to 170 deg. F. and that it will not crack or check when subjected to freezing. It has been found that it is extremely flexible, thus allowing for reasonable distortion of material during handling.

Service connections are made in the usual manner for steel pipe and the pipe can be used on bell and spigot material where joints are caulked with molten lead.

Besides its adaptability for water service, it has been recommended for drainage lines in various indus-

trial processes. It is not intended, of course, for lines carrying naphtha, benzine or other solvents of bituminous material. The new pipe is manufactured by the National Tube Co., Frick Bldg., Pittsburgh, Pa., which is issuing an illustrated 12-page bulletin describing it in detail.

Air-Cushioned Compressor Valve

DESIGNED for simplicity, durability and efficiency, an improved air-cushioned valve for its air compressors has recently been developed by the Pennsylvania Pump & Compressor Co., Easton, Pa. As shown, the valve consists of four principal parts: seat, guard, discs and springs.

Special malleable metal is used for the guard, while the seat is a close grained casting. Valve discs, of steel

VALVE DISCS, ON OPENING, ENTER AIR POCKETS THAT CUSHION THEM

made especially for this purpose, are guided by columns on the guard, which support the valve above the seat. Movement of the discs is accelerated by small spiral springs in the guard against which the discs rest.

As the valve opens, the discs, instead of striking the guard, enter the air pockets in the guard and these air pockets provide a cushion. This design is intended to produce smooth and quiet action.

This entire assembly is held together by a retaining ring that snaps into grooves around the edges of seat and guard. This construction is intended to eliminate bolts, screws or nuts that might loosen and fall into the cylinder. The function of the retaining ring is only to hold the parts together; the assembly is held to its seat in the cylinder by a clamp that presses only on the outside edge of the guard and does not press on the center of the valve seat, which might cause it to crack.

Combustion Control System

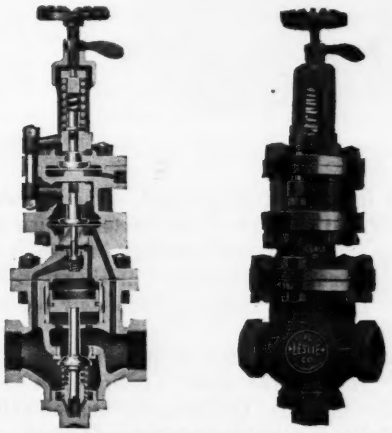
BY THE HAGAN Corporation of Pittsburgh, Pa., is announced a new system for the regulation of boiler plants, known as the Unit System of Combustion Control. In this system a unit control panel is located at each boiler and each unit panel in the plant is influenced by a centrally located, steam pressure-actuated master panel, from which all boilers are operated in unison in accordance with steam demand.

From the master panel, it is possible to hand-adjust the rating on all boilers, or throw the entire plant from automatic to complete hand control in case of emergency but impossible to make any adjustment of one boiler independently of the others or to affect the fuel-air ratio of any or all units. Only from the unit panels can adjustments be made to secure the correct fuel-air ratios or modify the response of each boiler to the central control panel. Adjustment made at one unit panel affects no adjustment of any other unit panel.

This system is intended not to replace the operator but to enable him to secure better results, automatically adjusting fuel, air and draft in accordance with the load variations, leaving the operator free to observe the results and to make such manual adjustments as may be necessary because of inherent inaccuracy of stokers or coal feeders as coal meters and of the boiler passes as a gas meter.

Pump Pressure Regulator

IN OPERATION of the Leslie improved pump pressure regulator, pump discharge pressure enters at the upper right-hand opening, acting on the lower side of the top diaphragm against the pressure of the regulating spring. Any motion of this diaphragm is transmitted by crossheads and rods to the controlling valve in the chambers below, thus altering the steam admitted, from the live steam chamber at the left, on top of the piston which operates the main steam valve.



SECTIONAL AND ASSEMBLED VIEWS OF LESLIE PUMP REGULATOR

If pump discharge pressure falls, the top diaphragm will be forced slightly downward by the spring above and the crossheads will move with it. The lower crosshead will increase the controlling valve opening, more steam will be admitted on top of the piston, which will move downward, thus increasing the opening of the main steam valve and speeding up the pump to increase discharge pressure.

It will be noted that no stuffing boxes are used and that action of the regulator will be as rapid as the transmission of steam pressure from the top to the middle chamber. In installation, it is recommended

that a self-cleaning strainer be placed in the steam line, also that shut-off valves be placed on either side of the regulator, with a bypass line and valve around them, to permit cleaning the regulator without shutting down the pump. Pump discharge pressure is regulated by the hand wheel on top of the regulator which controls the spring pressure on the top diaphragm.

This regulator is the product of Leslie Co., Lyndhurst, N. J.

Thermal Relay Gives Overload Protection for Motors

BECAUSE IT AUTOMATICALLY permits the safe overload capacity of the motor to be fully utilized, a new thermal overload device, placed on the market by the Westinghouse Electric and Mfg. Co., has many applications in the industrial field. The thermal device follows the heating curve of the motor; which means the motor will not shut down instantly in case of high, but harmless, overcurrent demands. As shown in Fig. 1, the new unit is small, rugged, completely enclosed and easily adjusted.

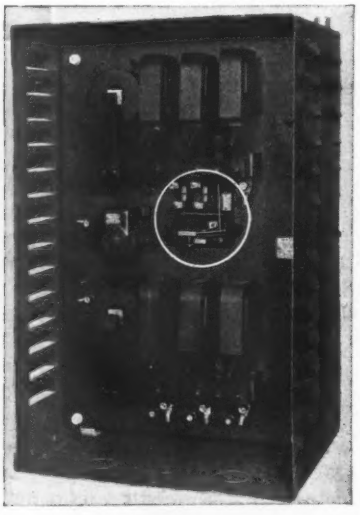


FIG. 1. THERMAL OVERLOAD RELAY

Excessive current may or may not mean a motor overload. Heat in the motor winding does the damage and not the fact that the ammeter momentarily swings off scale. Motor temperature depends on the length of time the current flows, as well as on the amount of current. If either factor is small, the other can safely increase and the machine will have the same temperature. The mass of iron and copper gives thermal capacity to the motor and the short high shots of current prove harmless because the generated heat is eagerly absorbed by the mass of relatively cold iron. The net result is a slight overall increase in temperature. Continued high current is a different matter; the surrounding metal soon becomes saturated with heat and the machine temperature starts climbing rapidly.

Figure 2 tells the entire story. The motor heating curve (A) and the thermal relay curve (B) track along together, because each is approximately proportional to the square of the current. The characteristic of the magnetic dash pot type of relay is shown dotted for comparison.

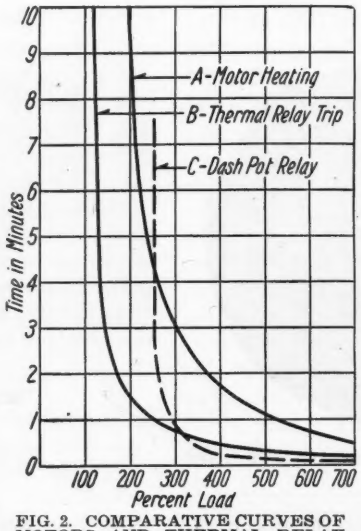
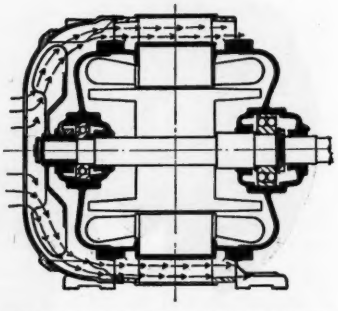


FIG. 2. COMPARATIVE CURVES OF MOTORS AND THERMAL RELAY

Wagner Air-Jacketed Motor

AN AIR-JACKETED motor for serving where dust, fumes and moisture are present in sufficient quantities to necessitate protection to motor and property, has been developed by the Wagner Electric Corp., St. Louis, Mo. The entire motor is surrounded by a jacket open at both ends with fan blades on a shaft extension, between the sealed motor and its outer jacket. The only clearance between rotating and stationary parts of the motor is in the bearing housing—and here no impurities can get past the grease packing.

These motors are new in external construction only; no changes have been made in the electrical principles of the motors themselves. The frame housing, the motor proper and all bearings are substantially air-tight. The end shield is made of cast-iron, rib-reënforced and has a substantial grating which protects the fan and provides an opening for incoming ventilating air. The center shield is made of heavy sheet steel held in place by slot head bolts. The fan is of one-piece construction. The conduit box is mountable in four positions. The stator is the only part of the standard single-phase repulsion-induction and polyphase squirrel cage motors subject to change in design. The exposed outer rim is deeply grooved to increase radiation surface. The punching for windings remains unchanged. The stator laminae are welded to lessen vibration and noise.



SECTION THROUGH WAGNER AIR-JACKETED MOTOR SHOWING PATH OF AIR

All motors have double row ball bearings, self-alining in one end plate and deep groove in the other to take end thrust. Bearings are grease lubricated, sealed in dust-proof housing. The shafts are made slightly longer than those for standard motors to permit fan mounting. Single-phase repulsion-induction motors may be had in sizes from one to 20 hp. and polyphase squirrel cage motors in sizes from two to 30 hp. These motors are designed for a temperature rise not to exceed 50 deg. C. and meet all A. I. E. E. and N. E. L. A. standards.

Die-Castings for Instrument Cases

USE OF DIE-CASTINGS for parts formerly cast or machined is one of the most rapidly growing practices in the assembly of metal products today. In this development, much work has been done by The Brown Instrument Co., Philadelphia, Pa. During the past several years this company has almost entirely swung over from using cast-iron instrument cases to the use of aluminum die castings for the cases and cover bezels of practically all models of its instruments.

Many of the die-castings required presented problems of extreme difficulty. The aluminum cases now standard for all Brown continuous chart recorders, for example, are among the largest aluminum die-castings ever produced on a quantity basis. The unusual size of these die-castings may be seen from the fact that dimensions of these cases are 15 in. high, by 13 in. wide, by 7 in. deep.

Die-cast aluminum cases cost substantially more than cast-iron cases, if the cost of the cases only is considered; however, this difference in first cost is largely overcome, the company states, by the savings effected by the perfection of detail assured by the die-castings process, which greatly reduces the grinding and machining necessary with iron castings.

To a great extent, the cases used for the different types of Brown instruments are of uniform dimensions. The uniformity of appearance provided by this standardization of cases greatly enhances the attractiveness of a complete installation of instruments covering principal process and power plant operating factors and, at the same time, largely helps to keep the cost of supplying these die-cast aluminum cases within the limits of practicability, it is claimed.

This change to die-cast aluminum cases is intended to assure instrument cases that are closely uniform in dimensions and quality, absolutely rustproof, resistant to corrosion, free from flaws, economical of freight and express charges and easy to handle in installation.

University of Louvain Receives War Memorial to American Engineers

ENGINEERING WAS EXTOLLED as the dominating force of the modern world in an address of the War Memorial Committee of American Engineers formally presenting to the University of Louvain, on July 4, a clock and carillon for the tower of the new Library Building. The ceremony took place in connection with the dedication of the Library. The address, in French, signed by all the members of the Committee, was handed to the Secretary of the University, Leon Van der Essen, by Dr. Edward Dean Adams of New York, chairman of the Committee and representative of the Engineering Foundation.

Secretary Van der Essen read the address, which recited that "To the glory of God and in memory of their fellow engineers who died in service during the Great War, 1914-1918, engineering societies of the United States of America present to the University of Louvain, the carillon and the clock installed in the tower of the Library of the University, the endowment fund of $10,000 for their maintenance, the Honor Roll of those who died and a record of the names of all those whose contributions have made this memorial possible."

The ceremony included the delivery of the deed of gift and trust by Arthur W. Berresford of New York, president of the American Engineering Council, and of a Memorial Record Volume containing the Honor Roll, description of the carillon, the clock and other parts of the engineers' memorial, and a list of contributors to the fund, by Alfred D. Flinn of New York, Director of the Engineering Foundation.

Colonel Arthur S. Dwight of New York, on behalf of the War Memorial Committee, presented to Louvain two flags, one bearing the insignia of the American Societies of Civil, Mining and Metallurgical, Mechanical, and Electrical Engineers, and the other that of the Society of American Military Engineers. The concluding event of the exercises was the presentation by Major L. R. Lohr of Washington, D. C., of a silk regimental flag of the United States.

Another engineering event of Independence Day at Louvain was the unveiling in the Library Building of a bronze bust of Herbert Hoover "in recognition of his humanitarian services to Belgium during the War and since."

Frederick W. Griffith

FREDERICK WINTERS GRIFFITH, who died July 11 in his California home in Pasadena in his 70th year, has been associated with the mechanical packing industry since its infancy. Mr. Griffith was born at Phelps, N. Y., December 17, 1858, received his education in the public schools and was graduated from Hamilton College with an A.B. Degree and membership in the Phi Beta Kappa.

At the time of his death he was President, Treasurer and member of the Board of Directors of The Garlock Packing Co., Palmyra, N. Y. He was one of the founders of the company and has helped supervise all its activities for over a period of 40 yr.

Mr. Griffith was a member of the Alumni Board of Trustees Hamilton Chapter Delta Epsilon and of the Hamilton College Board of Trustees. From 1910 to 1912 he was state senator in the New York legislature and had also served as presidental elector for the Republican party. He was trustee of the Auburn Theological Seminary of Auburn, N. Y., and had served as a member of the Palmyra Board of Education. He was a life member of the Palmyra Lodge of Masons; a member of Palmyra Eagle Chapter; Zenobia Commandery, Knights Templar; Nobles of Mystic Shrine and Rochester Consistory, Scottish Rite.

During the last 10 yr., Mr. Griffith traveled extensively, making a trip around the world 2 yr. ago. At the time of his death, he was preparing for a trip to Alaska.

SPRINGFIELD, ILL., plans expenditure of $100,000 upon improvement of its municipal electric light and power plant and distribution system, plans for the project being filed recently with Willis J. Spaulding, commissioner in charge of public properties. The Tenth and Robinson Street sub-station will be rebuilt, a new sub-station erected near the water reservoir on the south side and power lines extended and enlarged.

News Notes

BUNDY STEAM TRAP CO., Nashua, N. H., announces the appointment of Ralph V. Rich, Arcade Building, Norfolk, Virginia, as its official sales representative for Eastern Virginia.

IDEAL COMMUTATOR DRESSER CO., Sycamore, Ill., announce the production of a new solderless, tapeless wire connector which is to be known as their Large Universal type. It will take all combinations of wire from 4 No. 14 to 3 No. 10 wires.

FOLLOWING UPON the news of the recent purchase of The Chisholm-Moore Manufacturing Co., Cleveland, by the Columbus McKinnon Chain Co., Tonawanda, New York, comes the announcement that the former company will hereafter be known as Chisholm-Moore Hoist Corp. (Division of Columbus McKinnon Chain Co.).

ATLAS CONVEYOR CO., 20 So. Fifteenth St., Philadelphia, Pa., announces that A. J. Forschner has become associated with the company as vice president.

Mr. Forschner was formerly connected with the R. H. Beaumont Co. as sales manager of the sand, gravel and stone department and previously was president of Alfred J. Forschner Co., distributors for Sauerman Bros.

MAURICE A. OUDIN, vice president of the International General Electric Co., Inc., who has returned from an extended visit in Europe, was signally honored by the King of Italy. In recognition of his good offices in behalf of a closer international relationship and of the specific benefit to the engineering profession of Italy, Mr. Oudin was decorated with the Order of Commander of the Crown of Italy. The rank of commander is a high honor and is rarely bestowed upon a foreigner.

MAGNETIC MANUFACTURING CO., Milwaukee, Wis., announces a discontinuance of its former sales office and the opening of a direct factory branch office at 211 N. Desplaines Street, Chicago, Ill.

VAN DORN ELECTRIC TOOL CO., Cleveland, Ohio, announces that its sales branches in Los Angeles, San Francisco, and Seattle, and its Service Branches in Los Angeles, Oakland and Seattle have been supplemented by the establishment of a warehousing and service depot at 525 E. 10th St., Oakland, Calif.

AFTER 6 MO. investigation by Russian engineers, the Russian Soviet Government, through its representative, The Amtorg Trading Corp. of New York, has contracted with Graver Corp., Refinery Division, Chicago, for a complete pipe still installation, to have a capacity of 10,000 bbl. per day and be equipped complete with fractionating and condensing units.

EDGE MOOR IRON CO. held its regular annual sales meeting at the company's plant, Edge Moor, near Wilmington, Delaware, the early part of June. H. B. Bradford, vice president, presided. One of the principal topics of discussion at the meeting centered around the increasing high pressures being adopted by various industries. In this connection, the Edge Moor Iron Co. is now building two 650-lb. pressure boilers of 1174-b.hp. each, for the Waldorf Paper Products Co., St. Paul, Minnesota. This is possibly the highest pressure ever used in the paper industry. The first boiler will be shipped in August and will be in operation before the end of the year.

Other companies in the paper industry to adopt higher pressure boilers are West Virginia Pulp & Paper Co., who operate Edge Moor boilers at 425-lb. pressure. Two 825-b.hp. units were installed in 1927 and have been in operation just about a year. Two additional boilers of the same pressure and horsepower have been ordered and will be shipped in July of this year.

The Warren Manufacturing Co. is another concern in the paper industry to install high pressure boilers. At its Milford, N. J., plant this company has installed one 512-hp. Edge Moor boiler built for a working pressure of 385 lb.

CHICAGO PNEUMATIC TOOL CO., 6 East 44th St., New York, announces the appointment of W. S. Lynch, formerly district manager at Seattle, Washington, as district manager of Cincinnati office, Pearl and Vine Streets, to succeed T. G. Smallwood, who has been granted an indefinite leave of absence on account of ill health. A. M. Andresen has been appointed acting district manager at 1743-47 First Avenue South, Seattle, Washington.

WILLIAM PESTELL, vice-president of the Riley Stoker Corp., Worcester, Mass., died early on the morning of July 10, while on a train going to New Orleans. Mr. Pestell, born 56 yr. ago in Rutland, England, has been a resident of Worcester for almost 20 yr. Since 1914, he has been with Riley Stoker Corp., first as district manager, then as sales manager and, in 1927, as vice-president. Previously, he had been superintendent of power for the Lynn & Boston Street Railway Co., the Rhode Island Co. and had been connected with Allis-Chalmers Mfg. Co. and J. G. White Engineering Co. He was a fellow of the A. I. E. E., member of A. S. M. E. and of other technical and fraternal organizations.

BLAKE R. VANLEER, assistant professor of mechanical engineering at the University of California, is resigning from that institution to accept the position of assistant secretary of the American Engineering Council. He will begin his new duties about September 1, with headquarters in Washington, D. C. Professor Vanleer has recently returned from Europe, where he spent 11 mo. as John R. Freeman scholar, studying hydraulic practice and research.

FARLIN, IOWA, POWER AND LIGHT CORP., a private concern, has sold its distribution in the village of Farlin to the Iowa Railway and Light Corp., which plans to rebuild the high line and install a new distribution system.

GENERAL CONFERENCE of manufacturers of pipe and pipe nipples, distributors and users of pipe nipples, held June 29, at the Department of Commerce, under the auspices of the Commercial Standards Unit, Bureau of Standards, approved Commercial Standards for Steel and Genuine Wrought Iron Pipe Nipples. Approved Commercial Standards specify that pipe nipples shall be made only from tested new full or short lengths and full weight steel pipe, free from buckles, bends, kinks, cracks, laminations, imperfect welds, rust, injurious sand marks or any other defects which might affect its strength or serviceability. For steel pipe nipples, the pipe shall otherwise conform in all respects with the A. S. T. M. Tentative Specification for Welded and Seamless Steel Pipe, while that for genuine wrought

iron pipe nipples shall be in accordance with A. S. T. M. Specification for welded wrought iron pipe No. A72-27. The conference agreed that the effective date for new production and clearance of existing stocks should be January 1, 1929. The Commercial Standards will be subject to annual review for revision by the standing committees.

J. G. White Engineering Co., 43 Exchange Place, New York, has plans under way for the construction of a power plant in connection with an electric smelter at Valdivia, Chile, for a new company now being organized under the name of Electro-Siderurgical de Valdivia, Ltd., which will operate both properties. The power station will be equipped for an initial output of 30,000 hp. and will be located in the Valdivia Lake district, while the smelting plant, to secure power supply from new station, will be situated at Port of Corral, and will be equipped for an annual output of about 50,000 tons of steel; a transmission line will be constructed between the two plants. The entire project is estimated to cost more than $5,000,000, and initial financing will be arranged with a bond issue of $4,000,000, soon to be offered in the United States.

United States Civil Service Commission announces open competitive examinations for associate civil engineer and assistant civil engineer, to fill vacancies in the Engineer Department at Large, War Department, throughout the United States.

Applications must be on file with the Civil Service Commission, at Washington, D. C., not later than August 15.

The duties of these positions are organizing and taking care of a field party and supervising its work in connection with the investigation and reconnaissance of streams with a view to determining the economic possibilities of their improvement for the purposes of navigation, of flood control, of irrigation and of power development. Full information may be obtained from the Commission, at Washington, D. C., or at the post office or customhouse in any city.

Books and Catalogs

The A. C. Commutator Motor, by C. W. Olliver; first edition, cloth, size 6 by 10 in., 282 pages, 185 illustrations. D. Van Nostrand Co., Inc., 8 Warren St., New York City, 1927; price, $7.50.

Because of the increasing demand for efficient speed regulation and the growing necessity for high power factor, this book on the a.c. commutator motor should be welcomed by all those who have occasion to use variable speed alternating motors.

As stated in the author's preface, there is for some reason which is difficult to appreciate, a rather strong prejudice against the a.c. commutator motor which affords an almost perfect solution to the problem of variable speed; not, perhaps, so much by itself as when combined with the more usual induction motor. It is the object of this book to attempt to break down any such prejudice and show that the future lies with such combinations as are described in the book.

The volume is divided into two distinct parts, the first part containing all the analytical treatment of the subject which has been made as comprehensive as possible, while the second is devoted to a non-mathematical explanation of the principal applications of commutator motors. A short study of commutation is included as a preliminary chapter, after which the various forms of single-phase motors are studied analytically in some detail, leading naturally to a chapter on the polyphase motor, in which an attempt has been made to give a clear description, in non-mathematical terms, of the principles underlying its theory. A further chapter is devoted to cascaded sets and although the analytical theory of these is undoubtedly involved, the author has attempted to give a simple form of general equation applicable to such combination. In this chapter, the question of power factor improvements and auto-compensated induction motors is thoroughly settled. In the second part of the book, certain of the more important applications are dealt with. Crane and lift motors and their methods of control are described.

Much of the theory of commutation and that of the single-phase commutator motor used in this book is based on the lectures of Marius Latour, whose work on these subjects is too well known to need any comment.

Modern Central Stations, Fourth section, published by the Ingersoll-Rand Co., A. S. Cameron Steam Pump Works, contains descriptions of the Edgar station, which operates at 1200 lb. pressure, the Trinidad, Tex, station, the New East River station in New York, the New Whippany plant in New Jersey, the Mad River Plant near Springfield, O.; Long Beach No. 3 plant, the 60,000-kw. unit in Huntley station, Buffalo, N. Y., Boiler Tests with Unit Mills at Cahokia, Mason City, Ia., plant, Hydro and Steam Developments for 1928. These are reprints of articles appearing in engineering journals bound in an attractive cover and should interest executives responsible for central station design and installation.

Ellison pointer draft gages of the new dial type, with both single and double pointers, are described and illustrated in a 4-page folder, Bulletin 11, issued by Ellison Draft Gage Co., 214 W. Kinzie St., Chicago, Ill.

Loose leaf bulletins held in a binder, covering tubular products, water storage heaters, double pipe condensers, liquid ammonia receivers and other heat transfer equipment have just been issued by Heat Transfer Products, Inc., a division of the Staten Island Shipbuilding Co., 90 West St., New York City.

Bulletin No. 140, describing a multiple-belt-driven, semi-portable air compressor unit, arranged for automatic start and stop control, has recently been issued by Pennsylvania Pump & Compressor Co., Easton, Pa.

Lux-Rich reports for June, 1928, contains a description of a Fire Circus at which demonstrations were given of the Lux system of fire extinguishing. These reports are published by Walter Kidde & Co., 140 Cedar St., New York, N. Y.

Carbex refractories are described in bulletin 163 recently issued by McLeod & Henry Co., Troy, N. Y.

Multi-Stage Centrifugal Cameron pumps are illustrated and described in a 30-page catalog issued by the Ingersoll-Rand Co., A. S. Cameron Steam Pump Works, 11 Broadway, New York. It is of unusually attractive appearance and gives detailed information as to construction and special features of two to six-stage units.

Power Plant Construction News

Ala., Mobile—The International Paper Co., 100 East Forty-second Street, New York, is reported planning a new kraft paper mill at Mobile, to cost close to $4,000,000, project to include power house, pumping station and industrial power equipment for mill service. R. J. Cullen is vice-president, in charge.

Ariz., Phoenix—The Arizona Supreme Court has approved a bond issue arranged by the Salt River Valley Water Users' Association, Phoenix, in amount of $5,100,000 for construction of Stewart Mountain power dam, power station and electrification of system, and work will proceed at early date. C. C. Cragin is superintendent, in charge.

Calif., Tracy—The Board of City Trustees plans purchase of pumping equipment and accessories in connection with proposed extensions in municipal waterworks.

Conn., Norwich—The American Thermos Bottle Co. plans installation of power equipment in a proposed addition reported to cost in excess of $100,000 with equipment.

Idaho, Twin Falls—The Idaho Power Co., Boise, plans construction of new power substation in the South Side district, Twin Falls, reported to cost in excess of $35,000 with equipment.

Ill., Chicago—The Produce Terminal Cold Storage Co., care of Henschien & McLaren, 1637 Prairie Avenue, architects, has broken ground for initial unit of proposed eleven-story cold storage and refrigerating plant on West Fifteenth Place, near Blue Island Avenue, reported to cost close to $2,000,000. A second unit will be built at a later date. Frank E. Roth is president.

Ind., East Chicago—The United States Gypsum Co., 300 West Adams Street, Chicago, Ill., will install power equipment in its proposed local gypsum products mill, entire project reported to cost more than $500,000.

Ky., Mayfield—The Carnation Milk Products Co., Oconomowoc, Wis., is said to be planning a boiler plant at its proposed local milk condensary, entire project to cost more than $350,000.

La., New Orleans—The Sewerage and Water Board, 526 Carondelet Street, George G. Earl, general superintendent, will receive bids until Sept. 6 for one 15,000 kw. turbine and pumps for drainage system, as per specifications at office noted.

Md., Baltimore—The Bethlehem Shipbuilding Corporation, Key Highway, will install power equipment in a new woodworking mill addition to cost $100,000, for which plans have been filed.

Mich., Lansing—The Motor Wheel Corporation will install power equipment in a proposed one-story addition, 75x500 ft., to cost about $100,000.

Mich., Saginaw—The Consumers Power Co., Jackson, Mich., is planning the construction of a new local power substation, with capacity of 12,000 kva., for service at new local plant of Chevrolet Motor Co., and other industries, estimated to cost $225,000. The Chevrolet plant unit will cost more than $2,000,000.

Minn., St. Paul—The Northern Pacific Railroad Co., Railroad Building, has filed plans for an addition to its power plant at Hamline and Como Streets, estimated to cost about $50,000. Boilers, stokers and auxiliary equipment will be installed.

Mont., Laurel—The Northern Pacific Railroad Co., St. Paul, Minn., plans installation of power equipment in proposed two-story steel car shop at Laurel to cost about $200,000.

Mo., Poplar Bluff—The City Council is planning installation of pumping equipment and auxiliaries in connection with extensions and improvements in the municipal waterworks, reported to cost about $200,000.

Mo., St. Louis—The Market Development Corporation, International Life Building, C. E. Richardson, president, has plans under way for a new cold storage and refrigerating plant, reported to cost in excess of $100,000. Henschien & McLaren, 1637 Prairie Avenue, Chicago, Ill., are engineers.

N. C., Charlotte—The Hudson Silk Hosiery Co., South Boulevard, has approved plans for a one-story boiler plant in connection with a new mill addition to cost about $70,000.

N. D., Tuttle—The Otter Tail Power Co., Fergus Falls, Minn., plans extensions in transmission lines and substation facilities at Tuttle, Wilton, Mooreton, N. D., and vicinity. Permission has been granted.

N. J., Carpentersville—The New Jersey Sand & Stone Co., Spring Lake, N. J., will install power equipment in connection with extensions and improvements at local plant of the Warren Sand & Gravel Co., to develop the present capacity, reported to cost more than $50,000.

N. J., Elizabeth—The American Copper Products Corporation, Bayway, will install power equipment in a new addition to cost about $90,000, for which plans have been filed.

N. Y., Amenia—The Department of Mental Hygiene, Albany, N. Y., is planning early call for bids for a new power house at the local Wassaic State School for Mental Defectives.

N. Y., Brooklyn—V. La Rosa & Sons, Inc., 9 Wycoff Avenue, plan installation of power equipment in a new six-story macaroni factory on Troutman Street to cost about $225,000. Henry J. Nurick, 44 Court Street, is architect and engineer.

Ohio, Toledo—The Toledo Edison Co. is planning expansion in local-steam-operated electric power plant to increase the capacity about 25 per cent. A 132,000-volt transmission line will be built to Sandusky, Ohio, and vicinity, with power switching station, etc. Entire program will cost close to $1,000,000.

Okla., Tulsa—The Spartan Aircraft Corporation, Tulsa, plans installation of power equipment in a new local plant to cost upward of $350,000, with equipment.

Ore., Klamath Falls—The Sewanua Box & Lumber Co. plans installation of power equipment in connection with proposed rebuilding of portion of mill recently destroyed by fire with loss in excess of $150,000.

Pa., Philadelphia—The Reading Railway, Reading Terminal, will soon begin the construction of a power substation at Twelfth and Windrim Streets, reported to cost in excess of $80,000 with equipment.

Pa., Pittsburgh—The Carnegie Steel Co., Carnegie Building, will install power equipment in a new addition to its mill on Lighthill Street to cost $300,000, for which plans have been approved.

Tenn., Nashville—The Radnor Water Co., Inc., Nashville, plans installation of pumping machinery and auxiliary equipment in a proposed new waterworks for service in the Radnor Heights and Flat Rock sections. Entire project is estimated to cost close to $200,000.

Texas, Houston—The Duval Texas Sulphur Co., Second National Bank Building, is planning purchase of two steam-driven air compressors, with capacity of 350 to 500 cu. ft. per min., and would be interested in used units.

Texas, Port Neches—The Atlantic Refining Co., 260 South Broad Street, Philadelphia, Pa., plans installation of boilers and other power equipment in a projected oil refining plant in this section, entire project reported to cost more than $600,000.

Vt., Pownal—The Commonwealth Portland Cement Corporation, recently organized, is reported planning the construction of a power house at a proposed new local cement mill. Entire project will cost in excess of $1,000,000.

Va., Richmond—The duPont Rayon Co., River Road, Buffalo, N. Y., plans installation of power equipment in proposed new mill at Ampthill, near Richmond, reported to cost in excess of $1,000,000. Work will soon begin.

Va., St. Charles—The Old Dominion Power Co., Louisville, Ky., is reported planning rebuilding of power plant near St. Charles, recently destroyed by fire with loss of more than $200,000, including equipment.

Wash., Seattle—The Northwest Lead Co., 1742 Fourth Avenue, South, will install power equipment in a new mill addition to cost approximately $80,000. John T. Lund is president.

Wis., Appleton—The Appleton Coated Paper Co., North Meade Street, will install power equipment in a new one-story addition, 110x240 ft., for which bids will be taken at once on general contract. Entire project will cost close to $150,000. Lockwood, Greene & Co., 400 North Michigan Avenue, Chicago, Ill., are architects and engineers.

Wyo., Buffalo—The Buffalo Northwestern Electric Co. is completing plans for an auxiliary steam-operated power plant on Clear Creek, near the city limits, reported to cost about $40,000.